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APPENDIX

VOLUME II

PAGES 401 - 1396

IN THE

Supreme Court of the United States

OCTOBER TERM, 1976

No. 76-419

VERMONT YANKEE NUCLEAR POWER CORPORATION,

Petitioner

v.

NATURAL RESOURCES DEFENSE COUNCIL, INC., ET AL.,

Respondents

No. 76-528

CONSUMERS POWER COMPANY,

Petitioner

v.

NELSON AESCHLIMAN, ET AL.,

Respondents

ON WRITS OF CERTIORARI TO THE UNITED STATES COURT OF APPEALS FOR THE DISTRICT OF COLUMBIA CIRCUIT

PETITIONS FOR WRITS OF CERTIORARI FILED SEPTEMBER 21 AND OCTOBER 14, 1976
CERTIORARI GRANTED FEBRUARY 22, 1977

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[SUMMARY OF APPLICATION

VERMONT YANKEE NUCLEAR POWER STATION
Ex. 3, pp. 2-5, AEC Dkt. No. 50-271]

SITE AND ENVIRONS

The site for the Vermont Yankee Nuclear Power Station is located in the town of Vernon, Vermont in Windham County on the west shore of the Connecticut River upstream of the Vernon Hydroelectric Station. The site consists of about 125 acres owned by the Vermont Yankee Nuclear Power Corporation and a narrow strip of land owned by New England Power Company and located between the Connecticut River and the boundary of the Vermont Yankee property and in which Vermont Yankee has perpetual rights and easements granted by the New England Power Company with the approval of the Federal Power Commission. The City of Brattleboro, Vermont is about five miles upstream of the site. There are no residences on the site, and the minimum distance from the reactor building to the boundary of the exclusion zone, as defined in 10 CFR 100, is 910 feet. The nearest town with a population of 25,000 or greater is Northampton, Massachusetts, about 30 miles to the south. Much of the land around the site is undeveloped. Most of the developed land is used for agriculture and dairying, with houses scattered or grouped in small villages. Appendix B appended hereto is a map showing the location of the site with respect to adjacent areas (FSAR 2.2).

In July 1969 Vermont Yankee initiated a comprehensive environmental radiation surveillance program designed to monitor the atmospheric, terrestrial and aquatic environments in the vicinity of the station. This program was developed in cooperation with the Vermont State Department of Health and reviewed by the Vermont Water Resources Board.

It is Vermont Yankee's intent that the environmental surveillance program will be closely coordinated with conditions of station operation by systematically correlating information developed through continuous in-plant monitoring, effluent release records and environmental sample collection and analysis. The primary purpose of the surveillance program is to make station management and the State Health Department aware of any conditions of station operation which may have a significant effect on the environment. The operational surveillance program will be a graded program subject to periodic critical review (FSAR 2.6).

Plant Design Bases Dependent Upon Plant Site and Environs Characteristics

Information relating to the site and environs for the Vermont Yankee Nuclear Power Station is presented in Section 2 of the FSAR. The design features which were dependent or affected by the site characteristics are summarized below.

Condenser Off-Gas System

The condenser off-gases will be discharged to the atmosphere through decay piping and a stack 308 feet above grade. The off-gas system is used during normal operation. It is expected that the release of gaseous radioactivity will be kept within small fractions of the limits specified in 10 CFR 20 based on the use of the off-gas system. However, to further minimize the release of gaseous radioactive wastes, Vermont Yankee will modify the off-gas system to provide additional holdup and subsequent decay of air ejector off-gases. The design of this advanced off-gas system is currently underway and fabrication and installation

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will be completed by the end of the first refueling outage (FSAR 9.4 and Appendix E).

Liquid Waste Effluents

Liquid effluents will be released from the radwaste dilution system at a point downstream of the aeration blocks in the station discharge structure. The liquid waste treatment system has been designed so that those liquid effluents which are released from the station are always well within the limits specified in 10 CFR 20. This is a batch-type system wherein the wastes are separately collected and processed based upon the most efficient methods. Batches of liquid radwaste are sampled and analyzed prior to discharge. If suitable for discharge, radwaste effluents are released at a rate such that the resultant concentration at the point of release will never exceed 10 CFR 20 nor the applicable state release limit. During each release, a continuous radiation monitoring device is set to alarm upon excessive activity concentration in the radwaste discharge line. Discharge records are maintained for all station liquid radwaste effluents.

Wind Loading Design

Plant structures are designed to withstand the effects of 80 mph winds with gusts to 110 mph. Although the probability of a tornado occurring at the Vermont Yankee site is small, all structures and equipment necessary to initiate and maintain a safe plant shutdown are designed to withstand a tornado wind loading of 300 mph (FSAR 2.3 and 12.2).

Hydrology

The site is at mile 138.3 above the mouth of the Connecticut River on the west bank on the pond formed by the

Vernon Dam and Hydroelectric Station. The maximum recorded water level at Vernon was 231.4 feet mean sea level which occurred during the flood of March 19, 1936. The minimum elevation of access openings to buildings housing important equipment is 252.5 feet mean sea level, more than 20 feet above the maximum observed water level. An analysis of water levels resulting from the probable maximum flood, a postulated occurrence which is more severe than the most significant historical event, has been performed and shows that the station is suitably protected against the maximum probable flood (FSAR 2.4 and Appendix I).

Geology

The site area is overlaid by glacial deposits, with an average of 30 feet of glacial overburden above the local bedrock. Major structures of the station, including the reactor building and turbine building, are supported on rock. Seismic velocity measurements at the site verified the hard massive nature of the bedrock and there were no indications of deeply weathered or faulted zones (FSAR 2.5).

Seismic Design

The maximum acceleration at the bedrock surface of the plant site from an earthquake is expected to be from 0.03g to 0.04g. Although this acceleration is considered to be conservative, the seismic design for structures and equipment important to safety are based on dynamic analyses using acceleration response spectrum curves together with a ground motion of 0.07g. The station is also designed so that the plant can be shutdown in a safe and orderly manner even if the ground acceleration were 0.14g (FSAR 2.5 and 12.2).

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SUMMARY DESCRIPTION OF THE FACILITY

3.1 Introduction

The nuclear steam supply system of the Vermont Yankee Nuclear Power Station utilizes a General Electric boiling water reactor identical in most design features to Monticello Unit No. 1, the operation of which was recently authorized by the Atomic Energy Commission. The design of the features of the Vermont Yankee facility is based upon power technology attained during the development, design, construction and operation of boiling water reactors of similar types, including the Monticello facility. These features include the basic fuel design, Zircaloy fuel cladding, hydraulically operated control rods, in-core neutron monitoring instrumentation, pressure suppression containment and radioactive waste control.

The following discussion summarizes the principal design features of the Vermont Yankee facility which are significant to safety considerations. The FSAR and subsequent amendments present an extensive technical description and evaluation of this facility and FSAR references elaborating on the discussion below are given in each summary. Appendix C of this testimony gives a comparison of the significant station design features of Vermont Yankee to other boiling water power reactor stations. A drawing of a reactor and containment typical of the Vermont Yankee plant is shown in Appendix D.

3.2 *Reactor Primary System*

The reactor is a single cycle, forced circulation, boiling water reactor producing steam for direct use in the steam turbine.

The fuel for the reactor core consists of slightly enriched uranium dioxide pellets contained in sealed Zircaloy-2

tubes. These fuel rods are assembled into individual fuel assemblies of 49 fuel rods each. Each complete core loading consists of 368 fuel assemblies (FSAR 3.2).

Control of the reactor is achieved by movable control rods. Reactor power level control is augmented by controlling the recirculation flow rate through the reactor core. The core is designed so that the reactor can be shutdown from any point in its operating cycle by control rods alone. Stored energy will be available from reactor pressure and gas-charged accumulators to insert all control rods simultaneously for rapid shutdown of the reactor (FSAR 3.4).

In addition, there is provided a standby liquid control system containing a boron neutron-absorbing solution which is capable of shutting down the reactor and maintaining it in a shutdown condition. This system is an independent system that would be used to shutdown the reactor in the unlikely event that shutdown cannot be accomplished with the control rod system alone (FSAR 3.8).

The reactor pressure vessel contains the reactor core and supporting structure, the steam separators and dryers, the jet pumps, the control rod guide tubes, the feedwater and core spray spargers and other components. The main connections to the reactor vessel include the steam lines, reactor coolant recirculation lines, feedwater lines, control rod drive housings and other connections for core cooling. Appendix E is a cut-away view typical of the reactor vessel and core arrangement (FSAR 3.3).

Reactor Coolant will enter the reactor near the bottom of the core and flow upward through the fuel assemblies. The heat from the nuclear reaction will produce a mixture of steam and water. The steam will be separated from the water by means of steam separators and dryers located in the upper portion of the reactor vessel, and will then pass

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through steam lines to the turbine. The separated water will mix with the incoming feedwater within the reactor vessel and the total flow will be returned to the core inlet through jet pumps located in the vessel. The motive force for the jet pumps will be supplied by the water discharged from two reactor coolant recirculation pumps. Variable frequency motor-generator sets supply power to the recirculation pump motors.

The design, fabrication, erection, testing, and certification of the reactor pressure vessel are discussed in detail in Amendment No. 13 to the license application (application dated December 2, 1966, Docket No. 50-271).

The plant has removable insulation in specified areas which permit direct inservice inspection of the exterior of the reactor vessel and other primary system components. This permits inspection of selected nozzle-to-shell welds, inspection of reactor vessel studs, nuts and bushings, selected sampling of high cyclic stress vessel welds, and selected sampling of coolant system piping, pumps, valve supports, and hangers. Inspection of the interior of the reactor vessel can be accomplished under water using remotely operable lights and visual aids such as borescopes and underwater TV cameras. (FSAR 4.2.6, 4.3.6, 4.4.8, and Section 4.6 of the Vermont Yankee Technical Specifications.)

3.3 *Plant Containment System*

The primary containment system, consisting of a steel light-bulb-shaped drywell, a steel doughnut-shaped pressure suppression chamber, and interconnecting vent pipes, provides the first containment barrier surrounding the reactor vessel and reactor primary system. Any leakage from the primary containment system is to the secondary contain-

ment system which consists of the reactor building, the plant standby gas treatment system, and the plant main stack. The integrated plant containment system and its associated engineered safeguards features is designed so that off-site doses resulting from postulated design basis accidents are well below the reference values stated in 10 CFR 100.

3.3.1 *Primary Containment System*

The primary containment is designed to accomodate the pressures and temperatures which would result from, or occur subsequent, to, a failure equivalent to a double-ended, circumferential rupture of a reactor coolant recirculation system line within the primary containment resulting in the loss of reactor water at the maximum rate. The pressure suppression chamber is a steel, torus-shaped pressure vessel approximately half filled with water, and . . . .

**[USAEC STAFF SAFETY EVALUATION,
VERMONT YANKEE NUCLEAR POWER STATION,
Ex. 9, p. 5, AEC Dkt. No. 50-271]**

. . . . connected by vent pipes to the doughnut-shaped steel water-filled suppression chamber (torus). The reactor vessel and the recirculation water piping, valves and pumps are housed in the drywell. The reactor is a direct-cycle, forced circulation, boiling water system which produces steam at 1000 psig. The reactor core uses slightly enriched uranium dioxide fuel in the form of pellets contained in Zircaloy tubes. Water, which serves as both the moderator and coolant, is pumped upward through the core where it boils due to the heat produced in the core. Two recirculation loops, each with a pump, provide the driving flow. The resulting steam is supplied to the turbine, which is directly coupled to the generator. After passing through the turbine, the steam is condensed, partially reheated and returned to the reactor.

SITE AND ENVIRONMENT

Site Description

The plant is located near the village of Vernon, Vermont, slightly less than four miles north of the Massachusetts state line. It is on the west bank of the Vernon Pond. The pond is formed behind the Vernon Hydroelectric Station dam one-half mile downstream on the Connecticut River. The west bank of the river forms the boundary between the states of Vermont and New Hampshire flows in a southeasterly direction in a narrow, steep-sided valley through the Pisgah Mountains. The terrain rises steeply from the valley floor in the vicinity of the plant and reaches the same elevation as the plant stack at a point 6300 feet from the plant. The site is bounded on the west by the village and on the . . . .

UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

IN THE MATTER OF	DOCKET
VERMONT YANKEE NUCLEAR POWER CORPORATION	No. 50-271
(VERMONT YANKEE NUCLEAR POWER STATION)	

ORDER DETERMINING OBJECTIONS TO INTERROGATORIES

On April 30, 1971, Intervenor Natural Resources Defense Council (NRDC) submitted various interrogatories to Vermont Yankee Nuclear Power Corporation, the Applicant herein. Objections to these interrogatories were filed by the Applicant which emphasized the difference between interrogatories and motions for production of documents, as defined in the Federal Rules of Civil Procedure and as adapted by the Atomic Energy Commission to its Rules for proceedings. Applicant, after stating its general objection based upon this difference, then waived a portion of its objection by agreeing to make requested documentary material available for inspection and copying by the Intervenors.

The Atomic Safety and Licensing Board adheres to its ruling respecting the general objection made by Applicant to interrogatories submitted by New England Coalition on Nuclear Pollution in its Order dated May 11, 1971, and reasons therefor will not be repeated but are incorporated as fully as though set forth herein.

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Applicant, in addition to a general objection which is sustained to the extent of the Order respecting New England Coalition on Nuclear Pollution interrogatories, also made specific objections to two main categories of interrogatories by NRDC which, however, were limited to one subject respecting the transportation and disposal of high level nuclear waste materials which will occur after leaving the plant site. The objection was upon the ground that off-site activities respecting such waste materials were not within the issues prescribed by the Commission for this proceeding.

Upon a consideration of the interrogatories and objections thereto,

IT IS ORDERED, in accordance with the Atomic Energy Act, as amended, and the Rules of Practice of the Commission, that the specific objection made by the Applicant respecting the transportation and disposal of high level waste products is sustained upon the ground that such considerations are not within the issues prescribed by the Commission for this proceeding, but rather are the subjects for other licensing activities.

ATOMIC SAFETY AND LICENSING BOARD

By SAMUEL W. JENSCH, *Chairman*

Issued:
May 11, 1971
Germantown, Maryland

AEC Docket No. 50-271

Applicant's Answers to

Interrogatories of

Natural Resources Defense Council

Served on

Vermont Yankee Nuclear Power Corporation

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UNITED STATES OF AMERICA

ATOMIC ENERGY COMMISSION

IN THE MATTER OF	DOCKET
VERMONT YANKEE NUCLEAR POWER CORPORATION	No. 50-271
(VERMONT YANKEE NUCLEAR POWER STATION)	

AFFIDAVIT OF DONALD E. VANDENBURGH

Now comes Donald E. Vandenburgh, and being on oath, deposes and says as follows:

1. That he is a Vice President of Vermont Yankee Nuclear Power Corporation.
2. That attached hereto, are the answers to the interrogatories propounded in the above entitled matter to Vermont Yankee Nuclear Power Corporation by Natural Resources Defense Council; and that there is also attached certain "Supplementary Information — IV Transportation: High Level Wastes from the Plant" which should be considered as supplementing the answers given with respect to Interrogatories Nos. IV.1-6, IV.(DIS).2, 4-6.
3. That in the preparation of these answers, he has consulted with the following individuals with regard to the questions set forth next to their names below:

Name	*Numbers*
R. M. Grube	I.1-7, V.1-18
R. J. Merlino	II.1-3, IV.1-22 IV(DIS) 1-8
W. P. Johnson	III.1-9
J. W. Stacey	IV(DIS) 9 and 10

4. That the answers attached hereto, are true and correct to the best of his knowledge and belief.

5. That on the advice of council and in view of the rulings of the Board with respect to certain objections sustained to the interrogatories, no answers are included for questions I.7 and IV.(DIS) 8.

DONALD E. VANDENBURGH
DONALD E. VANDENBURGH

COMMONWEALTH OF MASSACHUSETTS

WORCESTER, S.S. June 1, 1971

Then appeared before me, the above subscribed Donald E. Vandenburgh and made oath that he is a Vice President of Vermont Yankee Nuclear Power Corporation; that he is authorized to subscribe to the answers of that corporation to the interrogatories of the Natural Resources Defense Council; that he has read the foregoing affidavit; and that the statements set forth therein are true to the best of his knowledge and belief.

Before me,

ARMAND R. SOUCY
ARMAND R. SOUCY — Notary Public
My Commission Expires September 9, 1977.

I. BASIC INFORMATION

QUESTION I.1

How long is it expected that the Vermont Yankee plant will run before being shut down for fuel reloading and removal of high level wastes from the reactor core?

ANSWER I.1

The first cycle of plant operation is expected to run for about 18 months before shutdown for refueling. At the first shut down, about 4% of the fuel assemblies will be removed and stored for reinsertion in a later cycle. At the end of the second cycle of about 12 months, about 40% of the fuel assemblies will be removed for shipment and reprocessing.

QUESTION I.2

How often is it expected that refueling and removal of high level wastes will be necessary?

ANSWER I.2

For cycles subsequent to the second cycle, it is expected that shutdowns for refueling and removal of spent fuel assemblies will occur about every 12 months when about 25-30% of the assemblies will be removed.

QUESTION I.3

Where will the high level wastes removed from the reactor core be stored prior to their removal from the plant site?

ANSWER I.3

After removal from the reactor core, irradiated fuel assemblies will be stored in the spent fuel storage pool under 23 feet of water shielding. Spent fuel storage is described in Section 10.3 of the VY FSAR.

QUESTION I.4

How long will the wastes be stored at the site before they are removed?

ANSWER I.4

Spent fuel assemblies are normally stored for a minimum of 3 to 4 months prior to shipment to a reprocessing plant. It is not expected they would be stored longer than a year prior to shipment.

QUESTION I.5

By what means of transportation will the wastes be taken away from the plant? If this is expected to change during the lifetime of the plant, describe each means and the period over which it is expected to be used.

ANSWERS I.5

The means of spent fuel transportation has not been selected. VY facilities can accommodate both truck and rail transportation. Any means of transportation will be in compliance with government regulations. During the lifetime of the plant, more than one means of transportation could be used.

QUESTION I.6

If the wastes are to be reprocessed, at what plant or plants will this be done? If this is to change over the life of the plant, specify the periods during which each reprocessing plant or plants is/are to be used.

ANSWER I.6

It is planned that all VY spent fuel will be reprocessed. A plant for reprocessing VY's spent fuel assemblies has not been selected. The following reprocessing plants are now in operation, under construction, or planned for the

time period when the first batch of VY spent fuel will need to be reprocessed.

1. The Nuclear Fuel Services, Inc. plant in operation, at West Valley, New York.
2. The General Electric Co. plant under construction, at Morris, Illinois.
3. The Allied-Gulf Nuclear Services plant, under construction, at Barnwell, S.C.
4. The NUMEC Atlantic-Richfield plant, planned to be located at Leeds, S.C.

Over the life of the VY plant, several different reprocessing plants could be used.

QUESTION I.7

If the wastes are to be reprocessed at a reprocessing plant:

a.) Describe where the resulting reprocessed waste materials will be taken from the reprocessing plant. Include description of where reprocessed materials to be disposed of are to be taken, and where any other materials are to be taken. If this is expected to change during the life of the plant, give this description for each relevant period.

b.) By what means of transportation will each segment of the reprocessing wastes be taken to each of these destinations? If this is to change over the period of the plant's life, specify the means during each phase of the plant's life.

c.) Where will the waste products which must be disposed of be taken? If this is to change during the life of the plant, describe where the wastes are to be taken during each phase of the plant's life.

ANSWER I.7

We are advised by legal council that in view of the Board's findings, no answer is required.

QUESTION II.1

Describe in detail the procedures to be used to remove the radioactive materials from the reactor in order to allow for refueling, including, but not limited to:

a.) How is the reactor core vessel to be opened and processed to assure that no radioactivity escapes from the containment vessel during this process?

b.) What is the chemical and radiological composition of the materials which will be removed from the core at that time?

c.) What toxic chemical compounds will be present in this process, in what quantities and proportions?

d.) What radioisotopes will be present in the material removed from the reactor core at this time? List them, including the quantity expected of each, the proportion of the isotope to the total radioactive isotopes present, the total amount of radioactivity represented by each type of isotope (expressed in appropriate units), and the half-lives of each isotope.

ANSWER II.1

a.) The reactor is first shut down and cooled down. The top of the primary containment vessel is removed to expose the top of the reactor vessel. The bolted head of the reactor vessel is removed and the area flooded with about thirty feet of water. All subsequent operations are carried out under water. Core internals are removed and stored under water. The spent fuel is then removed and placed in special underwater storage racks within the reactor building. New fuel is then

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installed into the core and the previous steps are reversed to place the reactor in operation again.

Under normal conditions and operations, no radioactivity will escape. The entire refueling area is surrounded by the reactor building which is automatically isolated should an incident occur which results in the release of any radioactive material. Section 14.6.4 of the FSAR, discusses the postulated radioactive release in the event of a refueling accident.

b.) Entire sealed fuel assemblies are removed during refueling. The chemical composition of the fuel is basically unchanged, that is an oxide, which now contains fission products which are listed in d.) below.

c.) No processing takes place at Vermont Yankee and no toxic chemical compounds are present.

d.) Attached are two lists which present the significant radioisotopes one day after shutdown, which is the earliest that fuel can possibly be moved. One list is of fission products and the second is an estimate of other significant radio-nuclides present in a single spent fuel assembly. The normal refueling procedure removes only about ¼ of a core during each shutdown (about 92 assemblies).

VERMONT YANKEE
FISSION PRODUCT INVENTORY
1 Spent Fuel Assembly
1 Day Decay

NUMBER	ISOTOPE	HALF-LIFE (SEC.)	CURIES AFTER 1 DAY DECAY	RATIO TO TOTAL
1	BR83	0.829E 04	0.158E 02	0.361E–05
2	BR84	0.198E 04	0.278E–08	0.635E–15
3	BR85	0.180E 03	0.000E 00	0.000E 00
4	BR87	0.563E 02	0.000E 00	0.000E 00
5	I129	0.505E 15	0.433E–02	0.990E–09
6	I31A	0.695E 06	0.896E 05	0.204E–01
7	I31B	0.695E 06	0.126E 05	0.290E–02
8	I132	0.828E 04	0.135E 06	0.309E–01
9	I133	0.755E 05	0.115E 06	0.264E–01
10	I134	0.315E 04	0.895E–02	0.204E–08
11	I135	0.241E 05	0.197E 05	0.451E–02
12	I136	0.840E 02	0.000E 00	0.000E 00
13	KR3M	0.686E 04	0.685E 02	0.156E–04
14	KR5M	0.158E 05	0.114E 04	0.260E–03
15	KR85	0.334E 09	0.167E 04	0.383E–03
16	KR87	0.468E 04	0.270E 00	0.617E–07
17	KR88	0.100E 05	0.356E 03	0.813E–04
18	KR89	0.192E 03	0.000E 00	0.000E 00
19	XE1M	0.103E 07	0.644E 03	0.147E–03
20	XE3M	0.198E 06	0.559E 04	0.127E–02
21	XE33	0.459E 06	0.244E 06	0.559E–01
22	XE5M	0.935E 03	0.598E 04	0.136E–02
23	XE35	0.326E 05	0.293E 04	0.671E–03
24	XE37	0.234E 03	0.000E 00	0.000E 00
25	XE38	0.101E 04	0.689E–20	0.157E–26
26	SE81	0.108E 04	0.134E–19	0.307E–26
27	SE3M	0.672E 02	0.000E 00	0.000E 00
28	SE83	0.150E 04	0.387E–13	0.886E–20
29	SE84	0.119E 03	0.000E 00	0.000E 00
30	RB88	0.108E 04	0.401E 03	0.916E–04
31	RB89	0.900E 03	0.290E–23	0.663E–30
32	RB90	0.161E 03	0.000E 00	0.000E 00

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NUMBER	ISOTOPE	HALF-LIFE (SEC.)	CURRIES AFTER 1 DAY DECAY	RATIO TO TOTAL
33	RB91	0.840E 03	0.231E–25	0.528E–32
34	RB92	0.800E 02	0.000E 00	0.000E 00
35	SR89	0.441E 07	0.179E 06	0.409E–01
36	SR90	0.884E 09	0.145E 05	0.332E–02
37	SR91	0.350E 05	0.405E 05	0.926E–02
38	SR92	0.972E 04	0.430E 03	0.982E–04
39	SR93	0.420E 03	0.000E 00	0.000E 00
40	SR94	0.119E 03	0.000E 00	0.000E 00
41	Y90	0.230E 06	0.145E 05	0.332E–02
42	Y91M	0.300E 04	0.256E 05	0.586E–02
43	Y91	0.529E 07	0.223E 06	0.511E–01
44	Y92	0.129E 05	0.743E 04	0.169E–02
45	Y93	0.359E 05	0.444E 05	0.101E–01
46	Y94	0.990E 03	0.125E–20	0.287E–27
47	Y95	0.630E 03	0.000E 00	0.000E 00
48	ZR95	0.563E 07	0.234E 06	0.535E–01
49	ZR97	0.613E 05	0.848E 05	0.193E–01
50	NB5M	0.323E 06	0.457E 04	0.104E–02
51	NB95	0.302E 07	0.244E 06	0.558E–01
52	NB7M	0.597E 02	0.834E 05	0.190E–01
53	NB97	0.444E 04	0.929E 05	0.212E–01
54	MO99	0.244E 06	0.184E 06	0.421E–01
55	MO01	0.900E 03	0.244E–23	0.558E–30
56	MO02	0.693E 03	0.477E–32	0.000E 00
57	MO05	0.119E 03	0.000E 00	0.000E 00
58	TC9M	0.215E 05	0.175E 06	0.401E–01
59	TC01	0.857E 03	0.502E–22	0.114E–28
60	TC2A	0.498E 01	0.480E–32	0.000E 00
61	TC2B	0.269E 03	0.781E–32	0.178E–38
62	TC05	0.597E 03	0.000E 00	0.000E 00
63	RU03	0.344E 07	0.112E 06	0.257E–01
64	RU05	0.161E 05	0.883E 03	0.201E–03
65	RU06	0.315E 08	0.128E 05	0.292E–02
66	RU07	0.287E 03	0.000E 00	0.000E 00
67	RH3M	0.341E 04	0.112E 06	0.257E–01
68	RH5M	0.450E 02	0.853E 03	0.194E–03
69	RH05	0.126E 06	0.227E 05	0.521E–02
70	RH06	0.300E 02	0.129E 05	0.295E–02
71	RH07	0.131E 04	0.169E–15	0.388E–22

NUMBER	ISOTOPE	HALF-LIFE (SEC.)	CURIES AFTER 1 DAY DECAY	RATIO TO TOTAL
72	SN27	0.741E 04	0.130E 01	0.297E–06
73	SN28	0.341E 04	0.340E–03	0.779E–10
74	SN30	0.156E 03	0.000E 00	0.000E 00
75	SB27	0.319E 06	0.443E 04	0.101E–02
76	SB28	0.597E 03	0.111E–04	0.255E–11
77	SB29	0.151E 05	0.729E 03	0.166E–03
78	SB30	0.597E 03	0.156E–02	0.357E–09
79	SB31	0.138E 04	0.164E–13	0.376E–20
80	SB32	0.126E 03	0.000E 00	0.000E 00
81	SB33	0.245E 03	0.000E 00	0.000E 00
82	TE7M	0.907E 07	0.133E 04	0.304E–03
83	TE7A	0.338E 05	0.380E 04	0.870E–03
84	TE7B	0.341E 05	0.797E 03	0.182E–03
85	TE9M	0.285E 07	0.131E 05	0.300E–02
86	TE9A	0.372E 04	0.532E 03	0.121E–03
87	TE9B	0.372E 04	0.130E 05	0.299E–02
88	TE1M	0.103E 06	0.954E 04	0.218E–02
89	TE1A	0.150E 04	0.469E–11	0.107E–17
90	TE1B	0.150E 04	0.217E 04	0.496E–03
91	TE32	0.280E 06	0.131E 06	0.300E–01
92	TE3M	0.378E 04	0.254E–01	0.580E–08
93	TE33	0.120E 03	0.128E–01	0.293E–08
94	TE34	0.263E 04	0.359E–04	0.821E–11
95	CS37	0.946E 09	0.144E 05	0.331E–02
96	CS38	0.192E 04	0.118E–07	0.270E–14
97	CS39	0.568E 03	0.000E 00	0.000E 00
98	CS40	0.660E 02	0.000E 00	0.000E 00
99	CS42	0.597E 02	0.000E 00	0.000E 00
100	BA7M	0.156E 03	0.135E 05	0.309E–02
101	BA39	0.509E 04	0.217E 01	0.498E–06
102	BA40	0.110E 07	0.227E 06	0.520E–01
103	BA41	0.107E 04	0.189E–18	0.432E–25
104	BA42	0.660E 03	0.000E 00	0.000E 00
105	LA40	0.144E 06	0.239E 06	0.547E–01
106	LA41	0.136E 05	0.316E 04	0.722E–03
107	LA42	0.509E 04	0.199E 01	0.456E–06
108	LA43	0.114E 04	0.352E–17	0.804E–24
109	CE41	0.276E 07	0.228E 06	0.523E–01
110	CE43	0.118E 06	0.137E 06	0.314E–01

NUMBER	ISOTOPE	HALF-LIFE (SEC.)	CURIES AFTER 1 DAY DECAY	RATIO TO TOTAL
111	CE44	0.246E 08	0.187E 06	0.427E–01
112	CE45	0.180E 03	0.000E 00	0.000E 00
113	CE46	0.840E 03	0.121E–25	0.277E–32
114	PR43	0.120E 07	0.222E 06	0.507E–01
115	PR44	0.105E 04	0.187E 06	0.428E–01
116	PR45	0.215E 05	0.937E 04	0.214E–02
117	PR46	0.144E 04	0.241E–12	0.551E–19
118	ND47	0.100E 07	0.787E 05	0.179E–01
119	ND49	0.719E 04	0.966E 01	0.220E–05
120	ND51	0.900E 03	0.205E–24	0.469E–31
121	PM47	0.794E 08	0.342E 05	0.782E–02
122	PM49	0.194E 06	0.302E 05	0.691E–02
123	PM51	0.100E 06	0.913E 04	0.208E–02
124	SM51	0.230E 10	0.110E 02	0.252E–05
125	SM53	0.169E 06	0.423E 04	0.966E–03

TOTAL = 0.4375E 07

VERMONT YANKEE

Other Significant Radionuclides In 1 Spent Fuel Assembly

ISOTOPE	HALF LIFE (Yrs)	MASS (Kg)
U-235	7.1×10^{8}	1.60
U-238	4.51×10^{9}	185.0
Pu-239	2.44×10^{4}	0.84
Pu-240	6.60×10^{3}	0.45
Pu-241	1.43×10^{1}	0.15

The total activity of these radionuclides is about 2×10^{4} curies.

QUESTION II.2

What impact would the chemical compounds described above, in the quantities which will be present at the time of refueling, have on the environment, including human beings, if they were to escape the containment vessel?

ANSWER II.2

As no chemical compounds are employed, no environmental effects are involved.

QUESTION II.3

What impact would the radioisotopes present in the materials removed from the reactor core vessel have on the environment, including human beings, if they were to escape the containment vessel? a.) Include short and long term effects, specifying the length of time each isotope would be dangerous to life. b.) Describe how these materials might be disseminated through the environment — for example, could they be disseminated through underground aquifers at the plant site, or by the Connecticut River, or by other means?

ANSWER II.3

Any release of these radioisotopes is considered unlikely since they are contained in sealed fuel tubes and no processing of the fuel is to be performed at the site. The only postulated incident involves the dropping of a fuel assembly while it is being moved from the reactor vessel to the storage pool. This operation is performed under water and within the confines of the reactor building. In the event the fuel assembly were dropped and significantly damaged, some of the fission product gases contained in the gap between the fuel pellets and the cladding might escape and rise to the surface of the storage pool. The analysis of this incident is presented in Section 14.6 of the FSAR.

QUESTION II.4

What facilities have been built into the plant to prevent an accident which would disseminate the chemical and/or radiological materials into the environment.

ANSWER II.4

As stated in the answer to question II.2, there are no chemical compounds employed in the nuclear coolant system, therefore, none can be released in the event of an accident.

Section 4 of the station Final Safety Analysis Report (FSAR) describes the reactor coolant system in detail. The reactor vessel and connecting piping systems which makeup the reactor coolant system provide a barrier against leakage of radiological materials into the primary containment. The reactor vessel is designed, fabricated, inspected and tested in accordance with the ASME Boiler and Pressure Vessel Code, Section III. Reactor coolant piping is designed and constructed in accordance with the USA Standard Code for Pressure Piping, Power Piping, USAS B 31.1.0, 1967. These codes require large safety margins between the design pressure for vessels and piping and the actual pressure where the material would fail.

Other requirements providing assurance of the reactor coolant system barrier integrity are the quality assurance and quality control programs employed during construction. In addition, an inservice inspection program will affirm continuing integrity of the coolant barrier throughout the life of the plans.

Section 7.2 of the FSAR describes the reactor protection system. This system is designed to provide protection against the onset of conditions that threaten the integrities of the fuel cladding and the reactor coolant system barrier.

The system continuously senses the pertinent reactor parameters and will automatically perform its safety function independent of operator action.

Reactor safety is further assured by operators who are skilled, highly trained men who must demonstrate their proficiency to the AEC Division of Reactor Licensing to qualify for their positions. The operator is trained to recognize conditions that could conceivably lead to a situation which would require action by the reactor protection system and to take action to safely shutdown the reactor.

In short, many considerations are taken into account in the design, fabrication, construction, testing and operation of a reactor plant to provide a high degree of certainty that an accident will not occur.

QUESTION II.5

Assuming that the chemical and/or radiological materials, or some part thereof, did escape the containment vessel, what plans exist for preventing further dissemination of them into the environment?

ANSWER II.5

This response is directed to the radiological aspects of the question since no chemical compounds are present in the reactor coolant system.

There are numerous station facilities built for the purpose of preventing dissemination of radiological materials into the environs in the event of an accident. Detailed descriptions of these facilities and how they function during accident conditions are a substantial part of the written work presented in the four volumes of the plant FSAR.

Section 5 of the FSAR describes the primary and secondary containments and the functions of each to mitigate

the effects of an accident. Section 14.6 of the FSAR presents analyses of various design basis accidents including responses of the primary and secondary containments to the design basis accidents where applicable.

Section 6 of the FSAR describes the systems (core standby cooling systems) which will automatically provide sufficient cooling to the reactor core in the event of a loss of coolant accident. Analyses for the various loss of coolant accidents are also presented in Section 6.

Section 7 of the FSAR describes the instrumentation and controls used for reactor protection circuitry, primary and secondary containment isolation circuitry, reactor core isolation cooling systems circuitry as well as other reactor control systems.

QUESTION II.6

Under what circumstances is it credible that the chemical and/or radiological materials described in the above schedule of questions, or any part thereof, could escape from the containment vessel? Supply any relevant studies upon which this judgment is based.

ANSWER II.6

As mentioned previously in answers II.2, II.4, and II.5, no chemical compounds are employed, therefore, the portion of the question pertaining to chemicals is not applicable.

Section 14.6 of the FSAR presents detailed analyses of the credible design basis accidents and the analytical results in terms of off site doses to the public. A credible design basis accident is a hypothesized accident the characteristics and consequences of which are utilized in the design of those systems and components pertinent to the preservation of radioactive material barriers and the re-

striction of radioactive material release from the barriers. The hypothesized accident is a "worst case" situation which, even though it is extremely unlikely ever to happen, is assumed to occur coincident with other highly unlikely events such as loss of off site electrical power and an earthquake. The doses are calculated based upon radiological materials escaping into the environs. The quantity of escaping radioactive materials are analytically determined based on a series of very conservative assumptions (conservative in that actual dose rates would likely be much less than those shown in the analysis).

Section 8 of the FSAR describes emergency electrical power circuits, components and sources (AC and DC).

III. FUEL HANDLING

QUESTION III.1

Describe the procedures by which fuel materials received at the plant gate will be processed and stored, specifying the accounting and security procedures which will be used to prevent accidental loss or theft of these materials during receiving, storage prior to loading, or while the fuel is being loaded into the reactor.

ANSWER III.1

The following procedure provides the answer to this question.

1.0 SCOPE

This procedure establishes requirements for the control of special nuclear material in the facility of Vermont Yankee Nuclear Power Corporation where such material is used directly or indirectly in the production of electrical energy. The materials involved in this facility are uranium and plutonium of various isotopic content. The nuclear

material control system involves the establishing of receipts from the shipper, six internal material balance areas, and records of shipments to a reprocessor or other licensed receiver as the means of maintaining control and accountability of all leased, or owned special nuclear material, or special nuclear material owned by others but residing in the facility of Vermont Yankee.

2.0 DEFINITIONS

2.1 Special Nuclear Material (SNM)

A. 10 CFR 70

Special Nuclear Material as defined by 10 CFR 70 is as follows: "(1) Plutonium, Uranium -233, uranium enriched in the isotope 233, or in the isotope 235, and any other material which the Commission, pursuant to the provisions of Section 51 of the act, determines to be Special Nuclear Material, but does not include source material, or; (2) any material artificially enriched by any of the foregoing but does not include source material."

B. Nuclear Material Control and Safeguards System For the purposes of these proceedings the following shall be considered to be units of special nuclear material:

1. Fuel Assemblies or separate fuel pins
2. Source Range Monitors (SRM's)
3. Intermediate Range Monitors (IRM's)
4. Local Power Range Monitors (LPRM's)
5. Traversing In-Core Probe Monitors (TIP's)
6. Subcritical Training Assembly

2.2 Material Balance Areas

For the purpose of maintaining control over the special nuclear material at the reactor site, the plant shall be divided into the following special nuclear material balance areas:

A. New Fuel Storage Vault

B. Spent Fuel Storage Pool

C. Reactor

D. Reactor Operating Floor

E. Warehouse

F. Training Laboratory

2.3 Authority and Responsibility

All special nuclear material on site shall be under control of the Reactor Engineer by direction of the Plant Superintendent. All reporting to the Central Accountability Office shall be done through the Reactor Engineer.

3.0 RECEIPT OF SPECIAL NUCLEAR MATERIAL

3.1 Each receipt of special nuclear material shall be accompanied by a bill of lading or packing list which contains a listing of the shipping containers involved in the shipment as well as a loading schedule for each shipping container. The loading schedule should show:

(a) The serial number of the shipping container

(b) The serial number of the individual units of special nuclear material contained in the shipping container.

(c) The type of special nuclear material.

3.2 A piece count of shipping containers shall be performed upon receipt and the serial numbers of the shipping containers received shall be compared with those shown on the shipping documents. Upon removal of the units of special nuclear material from the shipping containers, the serial numbers of the individual units of special nuclear material received shall be compared with those shown in the shipping documents.

3.3 After the unloading of each shipment the Central Accountability Office shall be notified of the date of receipt of the special nuclear material and the serial numbers of the units of special nuclear material using a pre-printed form, VY0002.

4.0 STORAGE OF SPECIAL NUCLEAR MATERIAL

4.1 The storage of all receipts of special nuclear material shall be in a Material Balance Area. Operations pertaining thereto shall be restricted to selected employees named by the Reactor Engineer and approved by the Plant Superintendent. There is no personal access to the new fuel vault.

4.2 A record shall be maintained of the contents of all storage locations showing the serial numbers of all units of special nuclear material received or removed, the dates of such receipts or removals, and the location of each unit of special nuclear material in the storage location.

4.3 Immediately upon removal of units of special nuclear material from their storage locations the Central Accountability Office shall be notified of the date of such removal, the serial numbers of the units of special nuclear material removed, and the

disposition of the removed units, — using preprinted forms, VY0003, and VY0004, VY0005 or VY0006.

5.0 REACTOR OPERATION

5.1 A unit of special nuclear material is introduced into or removed from the Reactor only during refueling.

5.2 The Central Accountability Office shall be promptly notified of the location of each unit of special nuclear material in the Reactor upon its introduction thereto, using VY0003 and VY0007 or VY0008 and of any relocation of units of special nuclear material during refueling operations using VY0007 or VY0008.

5.3 A record shall be maintained in the Reactor Control Room showing the serial numbers of the units of special nuclear material charged to or removed from the Reactor, the dates of such charging or removal, and the location of each unit of special nuclear material in the Reactor. At the conclusion of refueling the Central Accountability Office shall be furnished with a copy of the Core Fuel Assembly lay-out plan, VY0007, and in-core instrumentation lay-out form VY0008.

5.4 Immediately upon removal of irradiated units of special nuclear material from the Reactor, the Central Accountability Office shall be notified of the date of such removal, the serial numbers of the units of special nuclear material removed, and the disposition of the removed units using preprinted forms VY0003 and VY0009.

5.5 A member of the Plant Reactor Engineers staff at the Vermont Yankee site shall be responsible for the calculation of Core depletion and plutonium production. He shall also determine the placement of assemblies in the reactor at the time of refueling.

5.6 At the end of Core life the Central Accountability Office shall be notified of the depletion of special nuclear material by units in both total uranium and Uranium 235, and the plutonium production the Core has experienced during its residence in the Reactor, identifying each unit by serial number. During Core life at the end of each reporting period, using form AO-1, the Central Accountability Office shall be notified of the uranium depletion and plutonium production experienced in the Core during the period to be reported.

6.0 STORAGE OF IRRADIATED SPECIAL NUCLEAR MATERIAL

6.1 The storage of all irradiated units of special nuclear material shall be effected in a Spent Fuel Pool, which will be located in a controlled Access Area. Access to the area shall be restricted to selected employees.

6.2 The Central Accountability Office shall be notified of the location of each irradiated unit of special nuclear material in the Spent Fuel Pool upon its receipt, and of any subsequent change in location using forms VY0003.

6.3 A record shall be maintained in the Spent Fuel Pool area showing the serial numbers of the units of special nuclear material received at and removed from the area, the dates of receipt and removal

from the Spent Fuel Pool, and the location of each unit of special nuclear material. The location of the units of special nuclear material in the Spent Fuel Pool shall be recorded on VY0009 and a copy of this form shall be sent to the Central Accountability Office.

6.4 Immediately upon removal of irradiated units of special nuclear material from the Spent Fuel Pool, the Central Accountability Office shall be notified of the date of such removal, the serial numbers of the units of special nuclear material removed, and the disposition of the removed units — using a preprinted form VY0010.

7.0 SHIPMENT OF SPECIAL NUCLEAR MATERIAL

7.1 Each shipment of special nuclear material shall be accompanied by a bill of lading or packing list which shows the serial number of the shipping cask involved and a loading schedule which shows the serial numbers of the individual units of special nuclear material contained in the cask.

7.2 After the loading of each shipment, the Central Accountability Office shall be notified of the date of shipment of special nuclear material, the serial numbers of the units of special nuclear material shipped, the serial number of the shipping cask and the consignee of the shipment using form VY0010.

8.0 INVENTORY OF SPECIAL NUCLEAR MATERIAL

8.1 At least semi-annually a complete inventory of all new, irradiated, or Reactor contained special nuclear material shall be taken.

8.2 A physical inventory of new and irradiated units of special nuclear material shall be taken and their individual serial numbers recorded. The identity of units of special nuclear material contained in the Reactor Core shall be taken from Control Room records.

8.3 The special nuclear material content (isotope and element) of new units of special nuclear material shall be assumed to be that represented to be contained in each unit by the fabricator and which may be subject to inspection verfication.

8.4 The Central Accountability Office shall be notified by the site staff of the depletion of special nuclear material stated in both total uranium and Uranium 235 and plutonium production. The values so reported shall constitute the special nuclear material inventory of the Reactor Core.

8.5 The special nuclear material content (isotope and element) of irradiated units of special nuclear material shall be assumed to be that as computed and submitted to the Central Accountability Office as described in Section 5.6.

8.6 The limit of error in determining (or estimating) the amount of special nuclear material contained in the units of special nuclear material comprising the inventory shall be established and the overall measurement uncertainty for the inventory shall be determined by propagation of error techniques.

9.0 RECORDS AND REPORTS

9.1 The Central Accountability Office shall maintain records of receipts, transfers and shipments of spe-

cial nuclear materials as defined in Section 2.1B items 1 and 6 in each material balance area. These records shall show serial numbers for each unit of special nuclear material and the weight of contained special nuclear material (element and isotope), the composite limit of error associated with the determination of the latter, and a reference for the determination of the limit of error involved (such as the fuel fabricator's shipping document and the Reactor Engineer's calculated burn-up). These records shall be organized such that a running inventory of special nuclear material can be determined readily from the records.

9.2 The Central Accountability Office shall maintain records of receipts, transfers, and shipments of special nuclear materials held off-site by other licensees for Vermont Yankee is financially responsible for these materials. The Central Accountability Office shall also maintain records of materials owned by others but residing in the facility of Vermont Yankee. These records shall show the same information as set forth in (1), above.

9.3 The fabricator of units of special nuclear material shall provide a special nuclear material transfer document to the Central Accountability Office for each shipment of special nuclear material to Vermont Yankee. This transfer document shall contain, or shall have attached thereto, and made a part thereof, supplementary data sheets showing:

(a) Unit of special nuclear material identification numbers.

(b) Weight of special nuclear material (element and isotope) contained in each fuel assembly.

(c) The measurement uncertainty connected with the determination of the special nuclear material content of the material contained.

Additionally, it is desireable that the fabricator provide for Vermont Yankee, and Vermont Yankee will try to obtain the following information from the fabricator for units of special nuclear material furnished as fuel assemblies:

1) Fuel rod identification numbers for each fuel assembly.

2) Weight and lot number of fuel material in each fuel rod.

3) Weight of special nuclear material (element and isotope) contained in each fuel rod.

4) A correlation between the UO_2 pellet lots and the fuel rod numbers wherein the pellets are contained, and the results of special nuclear material analysis of each UO_2 pellet lot (element and isotope).

9.4 The documentation described in Section 3.3 concerning receipts of units of special nuclear material shall be checked against the special nuclear material transfer document provided by the shipping licensee. Discrepancies shall be investigated and resolved promptly.

9.5 The transfer document and the stated special nuclear material content of the units of special nuclear material shall be certified by a responsible member of the shipping licensee's management staff. The shipping licensee's values of the special nuclear material content units of special nuclear material shall be entered in the Accountability Ledger for Vermont Yankee on an individual basis.

9.6 Two Control Accounts shall be maintained showing total amount of special nuclear materials held on lease or owned. One Control Account shall show total uranium, Uranium 235, and total dollar valuation of the material leased or owned. The second Control Account shall show total plutonium total Plutonium 239 plus Plutonium 241, and dollar valuation of the material leased or owned.

9.7 The Central Accountability Office shall prepare a special nuclear material transfer document for each shipment of special nuclear material. This transfer document shall have attached thereto, and made a part thereof, VY0010 supplementary data showing:

(a) Unit of special nuclear material identification numbers.

(b) Estimated weight of special nuclear material (element and isotope) contained in each unit of special nuclear material as obtained from burn-up calculations described in Section 5.6.

(c) An estimate of the measurement uncertainty involved in the burn-up calculations.

9.8 The values shown on the transfer document for the special nuclear material content of the units of special nuclear material shipped shall be entered in the Accountability Ledger for the Power Reactor Facility on an individual shipment basis.

9.9 Upon receipt of the reprocessor's report of measurements of the special nuclear material content of the irradiated units of special nuclear material during reprocessing, and approval thereof, the Accountability Ledger shall be adjusted to reflect the results of the reprocessor's measurements.

9.10 The Central Accountability Office shall prepare a material balance for special nuclear materials for each six month period showing beginning inventory, receipts, shipments, burnup, ending inventory and the uncertainty connected with each.

QUESTION III.2

How long does the process of loading and reloading take?

ANSWER III.2

Loading and reloading is defined as the time required to remove designated used fuel from the reactor, relocate partially used fuel to new core positions and install new fuel into the reactor. The stated times *do not include* time for preparation and completion of loading such as reactor vessel head removal and replacement.

The process for loading and reloading the fuel initially will require twelve days. On subsequent reloadings after the plant has been operational, the twelve days will be reduced to approximately seven days. This reduction in time required on the subsequent reloadings is due primarily to the fact that some work can be accomplished prior to the refueling. Channeling, for instance, which consists of installing a fuel assembly into a shroud-like enclosure, is performed on a partial number of fuel assemblies prior to the actual loading operation.

QUESTION III.3

How many workers are involved in this process?

ANSWER III.3

The total number of workers involved in this process are twenty-one. This is broken down into seven per shift. The operation will involve around the clock work consisting of three shifts.

QUESTION III.4

What precautions are taken in the selection of personnel to handle this task to assure that none will steal or lose fuel materials during receiving, storage, or loading of fuel materials?

ANSWER III.4

All applicants for plant staffing are screened and interviewed in a manner that would disclose if any person is mentally disturbed. All applicants meet and are interviewed by a minimum of three plant supervisory staff members, who explore applicants background history and present and future goals.

QUESTION III.5

What precautions will be taken to assure that no nuclear material will be removed from the plant grounds by workers at the plant?

ANSWER III.5

A Station Security Program has been established to provide physical security, protection against impairment of necessary plant functions, and theft of Company equipment. A Security Force is established and is responsible to achieve these goals. The detailed Industrial Security Plan is considered to be proprietary since divulging its contents to the public would seriously impair its effectiveness.

The physical size and weight of the fuel is a major factor in preventing its removal from the plant site. Each assembly is approximately 14.5 feet long, 5.4″ x 5.4″ square and weighs approximately 580[1] pounds. Once fuel has been irradiated in the reactor, it has to be handled under water

[1] This is a typographical error in the original and should read "*680*" instead of "580". See FSAR (*Ex.* 1) §1.7, Table 1-7-1.

or in a heavily shielded cask. Such a cask would weigh many tons, requiring the use of a large crane to handle it.

QUESTION III.6

What is the percentage of nuclear fuel material expected to be lost, stolen, or otherwise unaccounted for at the plant site over the expected life of the plant, based upon previous experience of the Atomic Energy Commission?

ANSWER III.6

The percentage of nuclear fuel material expected to be lost, stolen, or otherwise unaccounted for at the plant site over the expected life of the plant is zero. Since we are unable to speak for the Atomic Energy Commission, this statement is based upon eleven years of operation at the Yankee Rowe Plant and four years of operation at the Connecticut Yankee Plant.

QUESTION III.7

What would be the maximum impact upon the environment, including persons, should this amount of material find its way into the environment outside the plant grounds?

ANSWER III.7

Since zero loss of nuclear material is expected, there would be no impact upon the environment.

QUESTION III.8

How much of the material expected to become lost, stolen, or unaccounted for at the plant site during the life of the plant, is expected to find its way into the environment, based on the past experience of the Atomic Energy Commission?

ANSWER III.8

Since none of the material is expected to become lost, stolen, or unaccounted for at the plant site during the life

of the plant, none is expected to find its way into the environment.

QUESTION III.9

Supply any relevant studies upon which the judgments called for above are based.

ANSWER III.9

The above judgments are based on a total operating experience of fifteen years. This operating experience consists of eleven years at the Yankee Nuclear Power Plant in Rowe, Mass. and four years at the Connecticut Yankee Haddam Neck Plant. During five of the years at the Yankee Rowe Plant, per agreement with the U. S. Government, the Plant was under voluntary inspection performed by the International Atomic Energy Agency. The purpose of these inspections was to verify that no nuclear material had been lost, stolen, or diverted from the Plant. It should be noted that the Yankee Rowe Plant was the only nuclear plant whose management volunteered to submit to such periodic inspections. The results of these inspections again verified that no nuclear material was lost, stolen, or unaccounted for at the Plant site.

V. TRANSPORTATION — FUEL FOR THE PLANT

Comment: New fuel shipped to the plant is in the form of fuel assemblies. The uranium oxide and mixed uranium-plutonium oxide is in the form of high density, ceramic pellets contained in sealed Zircaloy tubes which together with other hardware are assembled into fuel assemblies.

1. *Q.* Describe the package in which fuel will be delivered to the Vermont Yankee plant. Include information as to its weight, size, and markings.

A. The packages used for delivering fuel must be specially-designed for the type of fuel assembly and specially approved by the Atomic Energy Commission (AEC) and the Department of Transportation (DOT) prior to their use. A description of the package being used for Vermont Yankee's first fuel together with weight and size information is contained in Exhibit V-A. The package is marked in compliance with DOT regulations for shipping purposes as follows:

a. Consignee's name and address

b. Shipper's name and address

c. DOT Special permit number

d. Type of package

e. Transport Group number

f. Fissile Class number

g. Radioactive Material label

h. CG mark (Center of Gravity)

The package(s) to be used for subsequent fuel assemblies is unknown; however, it will comply with AEC and DOT requirements. The radioactivity level at the surface of the package is approximately 1 mr/hr.

2. *Q.* What amount of radioactive fuel material will be contained in each package? Express this in terms of mass — e.g. in kilograms — and in terms of its chemical composition and radioactivity (in appropriate units).

A. The fuel assemblies in each package contain approximately 440 kilograms of uranium dioxide (387 kilograms of uranium) and will have no more than 0.5 curies of radioactive material.

3. ***Q.*** **What percentage of the fuel to be used at the Vermont Yankee plant over its useful life will be plutonium: Give the information asked for in V.1 and 2 above with respect to this fuel material.**

A. It is planned to include in the first fuel used, four assemblies that are partially fueled with plutonium for the purpose of obtaining technical data. These assemblies are nearly identical in design to all-uranium assemblies, the major difference being that some of the sealed rods contain uranium-plutonium mixed oxide pellets rather than all uranium oxide pellets. The plutonium in these assemblies will comprise about 0.009% of the combined uranium and plutonium in the initial fuel loading. At some time in the future it is probable, after having obtained the required regulatory approvals, that plutonium will be used to replace some of the uranium in new fuel assemblies. If it is assumed that all plutonium produced in Vermont Yankee is used in new fuel as early as possible and is continued to be used until fast breeder reactors require plutonium for fuel, the schedule for new fuel insertion and its uranium-plutonium composition might be as follows:

Year of Plant Operation When New Fuel is Inserted	Percentage Composition of New Fuel	
	Uranium	Plutonium
0	99.991	0.009
1– 4	100	0
5–19	99.3–99.0	0.7–1.0
20–30	100	0

Therefore, it is expected that no appreciable quantity of plutonium will be used in new fuel until after 4-5 years of plant operation and that it will then be used

for a period of about 15 years. The package to be used for shipping the four part-plutonium assemblies will be the same as that used for all-uranium assemblies as described for Question V.1. The package to be used for future part-plutonium assemblies is unknown. All packages and shipments will comply with AEC and DOT requirements. The mass of material will be about the same as in V.2, above. The chemical composition of material in the sealed Zircaloy rods will be a mixture of uranium dioxide and plutonium dioxide. If future part-plutonium assemblies are similar in design to the first four the amount of radioactivity per container is estimated to be about 18,000 curies. Measurements on rods making up the first part-plutonium assemblies indicate a gamma activity of only 2 mr at a distance of 2 feet from the rods and 12 mr at a distance of one inch.

4. *Q.* How many packages of uranium fuel will be delivered on each truck/train (whichever will be used for delivery — both if both apply)?

A. The first fuel is being shipped by truck. Each truckload consists of up to 16 containers, each containing two fuel assemblies. It is not known whether future new fuel shipments will be by truck or by rail. Facilities for receiving both types of shipments exists at the VY plant. It is not known how many containers will, in the future, be loaded onto each vehicle. However, all shipments made will be in compliance with AEC and DOT regulations which specify limits for the number of containers on a vehicle.

5. *Q.* Where will this fuel be shipped from?

A. All of the first fuel assemblies (710,840 kg uranium) and 2.4 reloads of fuel assemblies (55,440 kg

uranium) are shipped from Wilmington, N. C. Since the manufacturers of subsequent fuel reloads have not been selected it is not known from what locations such reloads will be shipped.

6. *Q.* By what route will the fuel travel in order to reach the Vermont Yankee plant? Give route numbers of roads which will be used, specifying any cities through which trucks will pass. If railroad is to be used, specify cities through which the trains will pass and indicate clearly where these train routes are.

A. The route of first fuel shipments begins by taking US-421 from Wilmington, N. C. to its junction with Interstate-95; thence north on Interstate-95 to its junction with US-301 in Richmond, Va. Take US-301 north, bypassing Washington, D. C. to east and cross Chesapeake Bay via the Annapolis-Queenstown Bridge to Wilmington, Delaware. Through Wilmington and across the Delaware River over the Delaware Memorial Bridge on Interstate-295. Travel 295 to its junction with US-130. North on US-130 through Camden, N. J. but bypassing Trenton, N. J. to the junction of US-130 and US-1 and 9. North on US-1 and 9 over the George Washington Bridge in New York City to its junction with Interstate-95. East on 95 through Bridgeport, Conn. to New Haven where connection is made with Interstate-91. Through New Haven north on Interstate-91 through the cities of Hartford, Conn., Springfield, Mass. and Brattleboro, Vt. At Brattleboro connect with State Route-142 south to the plant site at Vernon, Vt.

7. *Q.* What, if any, calculations have been made to determine the chances of an accident involving fuel-

carrying vehicles over the life of the plant? If such calculations have been made, what are the results?

A. The National Safety Council publishes as public information, yearly statistics of all highway accidents, including as part of the report, truck accidents involving hazardous materials. These reports indicate there are so few nuclear fuel truck accidents each year that any statistic obtained by this method would not be of worthwhile significance if we attempted to use it as a life-of-the-plant vehicular accident probability factor. Note, however that in the event that an accident did occur involving nuclear fuel, simulated accident tests which the fuel containers have successfully withstood demonstrate that the fuel would remain intact, moreover even if through some catastrophic event, the fuel material (UO_2 pellets) were dispersed, no significant environmental effect would occur.

8. *Q.* What, if any, tests have been conducted using the type of containers in which fuel elements are to be shipped, to determine the conditions under which they might burst open or otherwise release radioactive material?

(a) Have any of these tests been conducted under actual conditions — involving dropping the container from a moving truck or train, for example — as opposed to in a laboratory with standard bursting and puncture tests?

(b) If such tests have been conducted, describe the tests and the results.

A. The fuel package tests conducted are the water immersion, fire and 30-foot drop tests. Specifications and standards are established by the AEC as pre-

scribed in 10CFR, Part 71: 31, 32, 34, 35, 36 and Appendices A & B and for the DOT as prescribed in 49CFR, Part 173:393 & 398. Results for first fuel packages are documented in Exhibit V-A.

(a) No tests for first fuel packages have been conducted under actual conditions involving dropping the containers from a moving truck or train.

(b) See (a).

9. *Q.* Describe the methods used to secure the containers in which fuel elements will be shipped to the Vermont Yankee plant to the trucks or railroad cars on which they will be shipped.

A. The method used to secure first fuel containers to the truck is to pass ⅜" steel link chain up the sides of the containers, over the top of the container block and down the other side. Both ends of the chain are hooked loosely to the trailer stake pockets. A chain binder is then placed at one side of the chain to pick up the slack in the chain. The slack is picked up one link at a time until the chain is so tight that one man using a length of steel pipe can scarcely close the binder. Three chains are used on each container or container block, spaced equi-distantly from each other along the length of the containers.

10. *Q.* Approximately how long will be required to release the containers from these fasteners? How is this accomplished?

A. Releasing the containers is accomplished by opening the chain binders. Normally, this requires very little time — 15 minutes at most. Subsequent unloading of the containers, however, is not so easily accomp-

lished because of their weight (2800 pounds each) and materials handling equipment is required.

11. *Q.* How many stops will be made between the time the truck(s) or train(s) leave the original shipping point and the time they reach the Vermont Yankee plant?

A. All first fuel shipments are by truck. Normally four to six stops are required by the truck from the time it leaves Wilmington, N. C. until arrival at the plant site at Vernon, Vt.

12. *Q.* What is the value, in dollars, on the present American market of the quantity of fuel to be shipped on each truck/train?

A. Each full truckload of 16 containers of the first fuel will carry fuel assemblies valued at $1,800,000. Of this, the value of the contained uranium is $1,000,000, the balance of $800,000 being for fabrication of the fuel assemblies. For the fuel assemblies as such, to have the full value of $1,800,000 to another party on the American market the other party would need to have a reactor nearly identical in design to VY in which to use them. For the contained uranium to have value to others, in itself, it would be necessary t. reprocess the assemblies to recover the uranium in a usable form. In addition to destroying the fabrication value, reprocessing could only be done at considerable expense which would effectively reduce the value of the uranium to others. If the uranium recovery were done in a reprocessing plant the uranium value would be decreased from $1,000,000 to about $800,000.

13. *Q.* What is its value on the international market?

A. On the present international market the situation would be essentially the same as for the American mar-

ket (Question 12) except that the contained uranium might be slightly less in value.

14. *Q.* What studies have been made to determine the likelihood of hijacking or theft of fuel or fuel containers during transit to the Vermont Yankee plant? Supply studies and describe their conclusions.

A. Although there have been no specific studies made to determine the likelihood of hijacking or theft of fuel during transit to Vermont Yankee, the manufacturer of the first fuel assemblies has an established fuel monitoring system requiring each vehicle transporting fuel to report its position and other important information by telephone every six hours during the trip to a responsible monitoring unit. This frequent telephonic surveillance of each shipment would quickly alert the fuel manufacturer to any attempted hijack or theft of nuclear fuel. Fuel shipments are made by direct sleeper truck-trailer service with two drivers and no transfer of equipment or drivers straight through to destination. The size and weight of the fuel containers would very likely preclude any theft or hijacking except by use of heavy duty special purpose handling equipment.

15. *Q.* What is the present best estimate of the chances of a hijacking or theft of fuel during shipment to the Vermont Yankee plant over the estimated life of the plant, assuming presently planned precautions are taken?

A. The present best estimate is that the chance of a hijacking or theft occurring during shipment of Vermont Yankee fuel is remote because of the precautions taken during shipment, and lack of any illegal use for

the material. To the best of our knowledge, there has never been a theft or hijacking, or an attempt at theft or hijacking, during the shipment of nuclear fuel assemblies.

16. *Q.* What would be the likely environmental impact, including impact on persons, of the release of radioactivity from a shipping container which was stolen or lost in transit, and later opened?

A. There is absolutely no environmental impact or effect on living creatures upon contact with or proximity to intact nuclear fuel assemblies because of their insignificantly low radiation level.

17. *Q.* How many containers of plutonium or other fuel would have to be stolen in order for someone who stole them to assemble enough material to create a critical mass?

A. If the fuel assemblies were removed from the containers and arranged closely in water criticality could be achieved with assemblies from two containers (that is 4 assemblies).

18. *Q.* How many such containers will be shipped to the Vermont Yankee power plant over its expected useful life?

A. Assuming the plant will have a useful life of 30[1] years it is estimated that 1700 such containers would be shipped during that period.

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[1] This is a typographical error in the original and should read "40" instead of "30".

EXHIBIT V-A

Description of Model RA-1 Package Used For Vermont Yankee's First Fuel Assemblies

1.0 *Package Description — Packaging*

(a) General: A right rectangular box consisting of a wooden outer container and a metal inner container separated by cushioning material.

(b) Gross Weight: 2800 pounds.

(c) Containment Vessel: A metal box consisting of an outer shell and perforated inner basket separated by structural angle iron. Outer shell formed of 16-gauge carbon steel plate with an integral welded end of same material. Four ⅛" thick one-inch angle stiffeners are welded on 4" centers to the outer surface of the end plate. Approximate dimensions 9" high, 18" wide and 174" long.

Inner basket of 16-gauge steel plate with ¾" perforations on 1¾" centers welded to upper edge of outer shell to form two U-shaped channels 6⅞" square which may be lined with cemented low-density cushioning with perforations matching size and location of those in basket.

Inner basket supported within inner shell by four ⅛" thick 3" x 3" angle iron spacers positioned longitudinally along entire length of body. Cover and end cap constructed similar to the box to provide 2" annulus around fuel when closed except at ends. A manually operable pressure relief valve passes 2 cfm air automatically at .5 psi pressure difference. Gasket of ½" thick hollow neoprene provides full seal with cover in place. Closure

effected by latches ("Camloc", 3711 series or equivalent) which are inaccessible during transport.

(d) Outer Container: Box 33″ high, 32″ wide and up to 207″ long fabricated of ½″ plywood, 2 x 4 cleated, on 2 x 6 tongue and groove platform with bolted 4 x 4 skids.

(e) Internal Cushioning: Three 3″ layers of ⅜″ cell phenolic resin impregnated kraft fiber honeycomb line the box at ends; one layer at top, bottom and sides. Remaining space at ends filled with expanded polyethylene cushioning. Three-inch-thick, 12″ wide pads of same material centered over transverse skids at sides, top and bottom. No attached lifting or tiedown devices.

2.0 *Package Evaluation*

A sample Model RA-1 package was subjected to the tests or assessments set forth in Subpart C of 10 CFR 71. Results of these tests and assessments were submitted for the AEC's review as part of the fuel manufacturer's application for an amendment to its special nuclear materials license for authorization to use container Model RA-1 for shipments of fuel assemblies. This evaluation data is given below.

2.1 General

There are no components of the packaging or its contents which are subject to chemical reaction in normal transportation environment. The package cannot be opened inadvertently, uses no coolant, and has no lifting devices or tiedown attachments.

2.2 Normal Transport Conditions

(a) *Thermal* — None of the components of the fuel assemblies or the inner metal container on which containment integrity and nuclear safety depend are significantly affected by temperatures within the range of −40°F to 130°F.

(b) *Pressure* — The breather valve opens automatically when the inner container is subjected to ∓.5 psi pressure differential. Therefore there is no effect on the packaging from an environment of .5 atmosphere.

(c) *Vibration* — A 6″ thick layer of cushioning material surrounds the inner metal container at the sides, top and bottom with an additional 3″ thickness at the ends. The Ethafoam cushioning is slightly compressed in final closure and banding of the outer container and is therefore not free to shift during transport. Since the latches on the metal container are pinned they cannot loosen during normal transport vibration or shock even were such vibration able to penetrate the cushioning material.

(d) *Water Spray and Drop Tests* — The complete package is designed to protect the fuel assemblies within the inner metal container from loss of containment integrity or change in nuclear safety reliability by virtue of the thick cushioning material surrounding it. The shock absorbing qualities of this material and of the heavy wooden cleats at the corners, edges and at all joints in the plywood, supplemented by the inherent resiliency of nails and

steel bands used in final closure of the outer package constitute a more than adequate buffer against the subject tests. This conclusion is further supported by analysis of high speed motion pictures recorded during the 30-ft drop test, described in Section 3.0, in which the flexibility of the package under impact is clearly evident.

(e) *Penetration* — Tests were conducted in which the flat circular end of a vertical steel cylinder 1¼" in diameter weighing 13 lbs. was dropped four feet onto the center of the ½" plywood outer container. No damage resulted after four drop tests.

(f) *Compression* — Tests were conducted in which six loaded packages were stacked. There was no visible nor measurable damage to the container on the bottom of the stack.

(g) *Reactivity* — In the normally undamaged condition, fuel assemblies are dry. Consideration was given to the effect of the hydrogenous outer packaging materials between adjacent metal containers. However, the analysis of water immersion of an infinite array of packages without water inside the inner container, described in detail in Section 3.1 below, demonstrates that condition would produce a more reactive array than the as-shipped condition. Results of conservative calculations of the as-shipped condition indicate a value for k_∞ of 0.8. This seemingly high value is partially explained by the degree of moderation of the packaging material and partially by the

conservative approximations, e.g., greater fuel size and assembly reactivity, than will actually be shipped. The criticality analysis conclusively demonstrates substantial subcriticality under all of the conditions of temperature, pressure, puncture, impact and exposure to incidental water during anticipated maximum potential damaging conditions of normal transport.

3.0 *Accident Evaluation*

3.1 Free Drop Test

Height:	30 ft. measured by weighted string hung from package.
Attitude of impact:	Long axis about 25° from vertical.
Impact surface of package:	Top edge of end which has the clamped end cap on the inner package. (From a series of drop tests of an earlier prototype, it was clearly established that the end cap and cover edge was the most vulnerable impact attitude. Previous drops also included flat on the cover surface and flat on the bottom.
Surface struck:	18″ thick concrete pad. Pad not damaged by test drop.
Contents:	Two simulated fuel assemblies each fabricated of ¾″ diameter steel rods 157″ long over a wood core and welded to typical reactor

fuel assembly hardware at both ends. Dummy dimensions: 6″ x 6″ x 174″ long; weight 632 lbs. each.

Results: Damage confined to impacted area. End of outer box separated from body exposing inner container but inner container still in position in outer container. End cap of inner container was still latched but gasketed surface not in contact with shell flange along one edge of end cap. Subsequent immersion would have permitted water leakage into inner container. End cap had to be unlatched and pried off with a tool in order to permit subsequent removal of cover and fuel assemblies. Two-inch annulus remained intact except in a 5″ long area at one end of the cover where resulting space averaged about one inch; an insignificant (1) portion of the total container surface.

3.2 Puncture Test

In view of the fact that the inner metal container remained firmly within the outer packaging and, since the inner package was properly designed to remain subcritical with water inleakage such as that which could result from a puncture, an actual puncture test was not conducted.

3.3 Thermal Test

An actual thermal test was not conducted but the outer packaging and cushioning material was assumed to

be completely consumed under thermal test conditions. However, the remaining inner package is constructed of noncombustible material and the minimum melting point of the fuel material is 4360°F. The pressure relief valve permits escape of heated air from the metal container. Therefore, this device would prevent rupture of the container even if the gasket did not melt to allow pressure relief. The 18-gauge steel container is internally braced with lengthwise angle iron on both sides and bottom; the cover is similarly braced. Previous tests of an 18-gauge 55-gallon drum in a jet fuel fire which exceeded an exposure temperature of 1475°F for more than 30 minutes produced no melting or distortion of the outer surface. It is therefore concluded that a similar thermal test at 1475°F for 30 minutes would result in no damage to the Model RA-1 container nor its contents more severe than the assumed conditions considered in the criticality analysis presented below.

3.4 Water Immersion Test

Since the package is designed to remain subcritical assuming any degree or credible mode of water inleakage, it was unnecessary to subject the package to an immersion test.

3.5 Analysis of Damaged Packages

From the above tests and assessments, the damaged package is assumed to be as follows:

(a) All materials outside of the inner metal container have been consumed by fire or otherwise removed.

(b) Package contents (fuel assemblies) remain inside the metal container.

(c) Metal container retains an annulus approximately 2″ thick around the fuel assemblies.

(d) The assemblies are of the most reactive type which could be shipped under the authorization requested herein, i.e., 5½″ square cross-section, 64 rods of 0.580″ diameter clad in 0.020″ zirconium at 5% U-235 enrichment. The geometric buckling of a reflected two-assembly container is 0.0188.

(e) The k∞ value of the assembly defined above is taken at 1.54. This value is conservative since the value used for design of fuel storage facilities including storage pools is 1.4; maximum k∞ values for presently planned fuel are approximately 1.3.

Based on the above factors, two cases were analyzed, namely, the flooded and nonflooded inner package. If the metal containers were flooded with water and closely "stacked" in an infinitely-large, three-dimensional array, the calculated k∞ value would be .954; a 250 container array would have a calculated k∞ value of 0.943. Assuming, more conservatively, the annulus thickness had in some manner been reduced over the entire surface of 250 containers from 2 to 1.5 inches, the array would still be subcritical.

In the second case, it was assumed that the metal containers were submerged in, or sprayed with, water but did not permit inleakage. Considering differing degrees of water moderation that could result from differing degrees of separation between

packages, a maximum k_∞ value of approximately 0.93 was calculated at the most reactive spacing of about 0.15 inches. The following table indicates values over the range of analysis:

Inches of water between containers	Value of k^∞ (Calculated)
0	.71
.15	.93
.50	.78
1.00	.69
1.50	.53

These calculations considered effects of interspersed moderation between the containers over a sufficiently wide range of moderation to demonstrate subcriticality under all credible conditions.

Calculative methods incorporated standard reactor design techniques utilizing Muft-type slowing down calculations with heterogeneous corrections to obtain two-group averaged epithermal cross-sections. Cross-sections averaged over the thermal range were obtained from solutions of the Wilkins equation combined with a P-3 approximation to the Boltzman equation. Accuracy of these techniques for systems of this type has been well demonstrated by reactor operating experience and other experimental data for similar systems. These methods are described in detail in Section 5 of the applications for license filed under these dockets.

Thus, regardless of whether water were present as the result of a spray, through immersion, or for any other reason, the fuel assemblies would remain subcritical in any number. This same calculation demon-

BLEED THROUGH

strates subcriticality also for the "as-shipped" packages in which the wood and plastic material, either wet or dry, contributes a certain degree of moderation because of its hydrogen content.

In summary, therefore, an infinite number of packages, either in the damaged condition or undamaged but in a water environment, would remain subcritical in any arrangement.

Supplementary Information

IV TRANSPORTATION: HIGH LEVEL WASTES FROM THE PLANT

1. *Basic Information*

Waste material will be in several forms at the Vermont Yankee plant. The largest source of waste material and the only source of high level waste material will be the spent fuel. Water treatment resins are used in various plant process streams to purify and remove radioactive constituents from them. The major portion of these exhausted resins are low activity. Other smaller quantities of miscellaneous radioactive wastes consisting of rags, floor sweepings, worn out equipment and paper will also require disposal. These items and their disposal will be discussed individually.

II. *Spent Fuel*

A. Description

The majority of all waste materials are contained within the spent fuel assemblies and are shipped intact to the reprocessor. The physical dimensions of a spent fuel assembly are identical to a new fuel assembly; about 14½ feet long x 5.4 inches square and weigh about 500[1] pounds. Over the 30-year lifetime of the plant, about 2600 fuel assemblies will be used and require shipment to a reprocessor; this is equivalent to approximately 3500 cubic feet and 1,300,000[2] pounds of waste material.

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[1] This is a typographical error in the original and should read *"680"* instead of "500". See FSAR (*Ex.* 1) §1.7, Table 1-7-1.

See also *supra* at A-26.

[2] This is a typographical error in the original and should read *"1,800,000"* instead of "1,300,000."

B. Spent Fuel Shipping Cask

Vermont Yankee intends to let a contract for the shipment of spent fuel and, if possible, to include the reprocessing in the same contract. The casks which will be used to transport the spent fuel are not known at this time so that only general design features can be discussed. The cask will be a large steel, lead and possibly depleted uranium shielded cask. If truck shipment is used, the cask will weigh in the neighborhood of 30 tons and one cask per truck will be shipped. A rail cask may weigh upwards of 100 tons and only one would be sent in each train. A truck cask could hold up to 6-8 spent fuel assemblies, while a rail cask would hold up to 20 assemblies. The cask will be designed and built to conform to all applicable regulations of the AEC and DOT in effect at that time. Present design conditions include the requirement to survive intact without leakage a 30-foot free fall and a 1475° fire for 30 minutes. Depending upon cask size, between 130-430 shipments may be anticipated over the life of the plant.

III. *Spent Resins*

A. Description

The Powdex resin is utilized at Vermont Yankee for system cleanup. The resins are finely divided solid particles which remove unwanted particulate matter by filtration and soluble ions by the ion exchange process. Approximately 1500-1800 cubic feet of this resin will be used annually at Vermont Yankee. All but about 65 feet of this will be relatively low level, approximately 0.3 curies per cubic foot. The remaining 65 cubic feet per year will be somewhat higher in activity and could approach 15 curies per cubic foot. Cobalt is expected to be major radioactive isotope present in this material when it is shipped. Co-58 is ex-

pected to make up 80-95% of the activity and Co-60 the remainder. When a resin bed becomes exhausted (usually chemically and not radioactively), water is added to make a slurry and it is pumped to the waste disposal area of the plant where a centrifuge will remove the excess water. Directly below the centrifuge is the resin shipping cask into which the resins are piped and remain until the cask is full. The resins in the cask with the free water removed would have a consistency quite similar to wet concrete.

B. Cask Description

Vermont Yankee is in the process of entering into a contract for waste disposal service in which the shipping casks will be supplied and the shipping and disposal handled by the contractor.

Two shipping casks will be utilized by Vermont Yankee, one heavily shielded cask of relatively low volume for the higher activity resins and a larger moderately shielded one for the lower activity resins.

The first cask consists of 1 inch structural steel shell, 3¾ inches of lead shielding, and ⅜ inch steel inner shell. The inner shell is designed as a pressure vessel to withstand 400 psi, although it is normally unpressurized. The cask is approximately 5½ feet in diameter and 5½ feet high and weighs a total of 45,000 pounds loaded. The total useable volume for waste is about 70 cubic feet. An additional disposable steel liner is placed within the cask prior to the resin loading operation.

Loading is accomplished through a small diameter hole in the center of the inner liner. When the cask is filled, the inner disposable leak tight liner is sealed with a non-removable cap prior to shipment. Depending upon the isotopes present, this cask can safely contain up to 3500

curies of waste. It is estimated that one shipment per year will be made with this cask.

The second cask has all the same design features of the first cask but is larger in outside dimensions, has about 1 inch of lead shielding, and will accept an inner liner of about 160 cubic feet capacity. The total loaded weight is also about 45,000 pounds. The dimensions of this cask are 7 feet in diameter and 7 feet high. It is designed to safely transport up to 185 curies of low specific activity waste, depending upon its isotopic makeup. Approximately 7-10 shipments per year will be made with this cask.

C. Transportation

Both of these casks are intended for truck transportation. One design limitation placed upon them is that the loaded cask trailer, tie-down devices, tractor and associated equipment will not exceed maximum legal weight limit for over-the-road transportation. This limit is presently 73,280 pounds. A single cask will be placed in the center of the trailer and firmly anchored in place. One cask per truck is all that can be transported.

IV. *Miscellaneous Wastes*

These wastes will be the normal wastes found around any machine shop, except they have the potential of being slightly contaminated with radioactive material. The normal procedure will be to place these wastes in open-top 55-gallon drums and sealing them when they are full. Normally these drums will be of such low activity that the waste disposal contractor would take them along with one of the larger casks for disposal. However, the larger shipping casks described previously are designed to accept a number of 55-gallon drums, so that shipments of higher activity drums will be shipped in an adequately shielded

container. The annual shipments are subject to variation, but they should not exceed 50 drums per year.

QUESTION IV.1

How many containers of waste materials, assuming the use of presently planned containers, will have to be shipped from the plant to some other location during the useful life of the plant?

ANSWER IV.1

Vermont Yankee estimates between 370 to 760 containers will be shipped over the 30-year life-time of the plant. Refer to Section II.B, III.B and IV of the Supplementary Information for the details.

QUESTION IV.2

Assuming present shipping arrangements, how many shipments of waste containers by truck will have to be made over the useful life of the plant? How many shipments by train?

ANSWER IV.2

Rail utilization would mean approximately 130 rail shipments and 570 truck shipments. If only trucks are used, approximately 760 shipments would be made. Refer to Sections II.B, III.B and IV of the Supplementary Information for details.

QUESTION IV.3

Describe in detail the package in which high level radioactive wastes will be transported to the reprocessing plant, or disposal site or both, if both apply. Include size, weight, and markings of the container, and a description of any systems in the container which will be required because of

the chemical and radiological composition of the waste materials.

ANSWER IV.3

Refer to Sections II B and III B of the supplementary information.

QUESTION IV.4

What physical state — e.g., solid or liquid — will the waste materials be in when they are transported?

ANSWER IV.4

Refer to Sections II A, III A and IV of the supplementary information.

QUESTION IV.5

What is the capacity of each container, and, if there is any difference, how much waste material will normally be shipped in each container?

ANSWER IV.5

Refer to Sections II B and III B of the supplementary information.

QUESTION IV.6

How many containers will be shipped on each truck or train, whichever applies (if both will be used, answer for both and indicate percentage of containers which will be shipped each way)?

ANSWER IV.6

Only one cask is sent per shipment, either truck or rail. The percentage is not known. Refer to Sections II.B and III.C of the Supplementary Information.

QUESTION IV.7

Describe in detail the chemical and radiological composition of the high level wastes. Include the following, and whatever else is relevant:

a.) What toxic chemicals will be present in the material shipped to the reprocessing plant, in what quantities, and proportions of the total material shipped in the container?

b.) What radioisotopes will be present in the material? List, with respect to the major ones:

1. The total mass of each isotope within the container;
2. the proportion of this mass to the total mass of the material within the container;
3. the total radioactivity (in appropriate units) accounted for by this isotope;
4. the proportion of this radioactivity in the same units to the total radioactivity within the container;
5. the half-lives of each isotope described.

c.) What is the total radioactivity (in appropriate units) which will be contained in each waste container?

ANSWER IV.7

a.) No toxic chemicals will be shipped with any of the waste material.

b.) With respect to spent fuel, attached is a table of the fission product inventory after 90 days decay, which is the minimum cooling time prior to shipment. The

table of significant radionuclides presented in response to Question II.1.(d) is also applicable here.

With respect to spent resins, refer to Section III.A of the Supplementary Information for the major radionuclides. The mass of radionuclides in comparison with the total mass is extremely small and has not been calculated. The half life of cobalt 60 is 5.3 years and the half life of cobalt 58 is 71.4 days.

c.) Refer to the table of fission product inventory after 90 days decay. This accounts for essentially all of the activity present in a single fuel assembly. The heavily shielded resin shipping container is not expected to contain more than 300 curies of Vermont Yankee wastes, and the moderately shielded cask is not expected to contain more than 50 curies of Vermont Yankee wastes.

VERMONT YANKEE
FISSION PRODUCT INVENTORY

1 Spent Fuel Assembly
90 Days Decay

NUMBER	ISOTOPE	HALF-LIFE (SEC.)	CURIES AFTER 90 DAY DECAY	RATIO TO TOTAL
1	BR83	0.829E 04	0.000E 00	0.000E 00
2	BR84	0.198E 04	0.000E 00	0.000E 00
3	BR85	0.180E 03	0.000E 00	0.000E 00
4	BR87	0.563E 02	0.000E 00	0.000E 00
5	I129	0.505E 15	0.433E–02	0.485E–08
6	I31A	0.695E 06	0.423E 02	0.474E–04
7	I31B	0.695E 06	0.659E 01	0.738E–05
8	I132	0.828E 04	0.763E–03	0.855E–09
9	I133	0.755E 05	0.275E–25	0.308E–31
10	I134	0.315E 04	0.000E 00	0.000E 00
11	I135	0.241E 05	0.000E 00	0.000E 00
12	I136	0.840E 02	0.000E 00	0.000E 00
13	KR3M	0.686E 04	0.000E 00	0.000E 00
14	KR5M	0.158E 05	0.000E 00	0.000E 00
15	KR85	0.334E 09	0.164E 04	0.184E–02
16	KR87	0.468E 04	0.000E 00	0.000E 00
17	KR88	0.100E 05	0.000E 00	0.000E 00
18	KR89	0.192E 03	0.000E 00	0.000E 00
19	XE1M	0.103E 07	0.104E 02	0.116E–04
20	XE3M	0.198E 06	0.161E–07	0.180E–13
21	XE33	0.459E 06	0.242E 01	0.271E–05
22	XE5M	0.935E 03	0.000E 00	0.000E 00
23	XE35	0.326E 05	0.000E 00	0.000E 00
24	XE37	0.234E 03	0.000E 00	0.000E 00
25	XE38	0.101E 04	0.000E 00	0.000E 00
26	SE81	0.108E 04	0.000E 00	0.000E 00
27	SE3M	0.672E 02	0.000E 00	0.000E 00
28	SE83	0.150E 04	0.000E 00	0.000E 00
29	SE84	0.119E 03	0.000E 00	0.000E 00
30	RB88	0.108E 04	0.000E 00	0.000E 00
31	RB89	0.900E 03	0.000E 00	0.000E 00
32	RB90	0.161E 03	0.000E 00	0.000E 00

NUMBER	ISOTOPE	HALF-LIFE (SEC.)	CURIES AFTER 90 DAY DECAY	RATIO TO TOTAL
33	RB91	0.840E 03	0.000E 00	0.000E 00
34	RB92	0.800E 02	0.000E 00	0.000E 00
35	SR89	0.441E 07	0.535E 05	0.600E–01
36	SR90	0.884E 09	0.144E 05	0.162E–01
37	SR91	0.350E 05	0.000E 00	0.000E 00
38	SR92	0.972E 04	0.000E 00	0.000E 00
39	SR93	0.420E 03	0.000E 00	0.000E 00
40	SR94	0.119E 03	0.000E 00	0.000E 00
41	Y90	0.230E 06	0.144E 05	0.162E–01
42	Y91M	0.300E 04	0.000E 00	0.000E 00
43	Y91	0.529E 07	0.818E 05	0.916E–01
44	Y92	0.129E 05	0.000E 00	0.000E 00
45	Y93	0.359E 05	0.000E 00	0.000E 00
46	Y94	0.990E 03	0.000E 00	0.000E 00
47	Y95	0.630E 03	0.000E 00	0.000E 00
48	ZR95	0.563E 07	0.909E 05	0.101E 00
49	ZR97	0.613E 05	0.155E–32	0.174E–38
50	NB5M	0.323E 06	0.186E 04	0.209E–02
51	NB95	0.302E 07	0.155E 06	0.173E 00
52	NB7M	0.597E 02	0.152E–32	0.171E–38
53	NB97	0.444E 04	0.170E–32	0.190E–38
54	MO99	0.244E 06	0.652E–04	0.731E–10
55	MO01	0.900E 03	0.000E 00	0.000E 00
56	MO02	0.693E 03	0.000E 00	0.000E 00
57	MO05	0.119E 03	0.000E 00	0.000E 00
58	TC9M	0.215E 05	0.626E–04	0.702E–10
59	TC01	0.857E 03	0.000E 00	0.000E 00
60	TC2A	0.498E 01	0.000E 00	0.000E 00
61	TC2B	0.269E 03	0.000E 00	0.000E 00
62	TC05	0.597E 03	0.000E 00	0.000E 00
63	RU03	0.344E 07	0.239E 05	0.268E–01
64	RU05	0.161E 05	0.000E 00	0.000E 00
65	RU06	0.315E 08	0.108E 05	0.121E–01
66	RU07	0.287E 03	0.000E 00	0.000E 00
67	RH3M	0.341E 04	0.240E 05	0.269E–01
68	RH5M	0.450E 02	0.000E 00	0.000E 00
69	RH05	0.126E 06	0.983E–14	0.110E–19
70	RH06	0.300E 02	0.109E 05	0.122E–01

NUMBER	ISOTOPE	HALF-LIFE (SEC.)	CURIES AFTER 90 DAY DECAY	RATIO TO TOTAL
71	RH07	0.131E 04	0.000E 00	0.000E 00
72	SN27	0.741E 04	0.000E 00	0.000E 00
73	SN28	0.341E 04	0.000E 00	0.000E 00
74	SN30	0.156E 03	0.000E 00	0.000E 00
75	SB27	0.319E 06	0.251E–03	0.281E–09
76	SB28	0.597E 03	0.000E 00	0.000E 00
77	SB29	0.151E 05	0.000E 00	0.000E 00
78	SB30	0.597E 03	0.000E 00	0.000E 00
79	SB31	0.138E 04	0.000E 00	0.000E 00
80	SB32	0.126E 03	0.000E 00	0.000E 00
81	SB33	0.245E 03	0.000E 00	0.000E 00
82	TE7M	0.907E 07	0.763E 03	0.855E–03
83	TE7A	0.338E 05	0.220E–03	0.247E–09
84	TE7B	0.341E 05	0.443E 03	0.497E–03
85	TE9M	0.285E 07	0.202E 04	0.227E–02
86	TE9A	0.372E 04	0.000E 00	0.000E 00
87	TE9B	0.372E 04	0.202E 04	0.226E–02
88	TE1M	0.103E 06	0.434E–18	0.487E–24
89	TE1A	0.150E 04	0.000E 00	0.000E 00
90	TE1B	0.150E 04	0.989E–19	0.110E–24
91	TE32	0.280E 06	0.740E–03	0.830E–09
92	TE3M	0.378E 04	0.000E 00	0.000E 00
93	TE33	0.120E 03	0.000E 00	0.000E 00
94	TE34	0.263E 04	0.000E 00	0.000E 00
95	CS37	0.946E 09	0.144E 05	0.161E–01
96	CS38	0.192E 04	0.000E 00	0.000E 00
97	CS39	0.568E 03	0.000E 00	0.000E 00
98	CS40	0.660E 02	0.000E 00	0.000E 00
99	CS42	0.597E 02	0.000E 00	0.000E 00
100	BA7M	0.156E 03	0.134E 05	0.151E–01
101	BA39	0.509E 04	0.000E 00	0.000E 00
102	BA40	0.110E 07	0.183E 04	0.205E–02
103	BA41	0.107E 04	0.000E 00	0.000E 00
104	BA42	0.660E 03	0.000E 00	0.000E 00
105	LA40	0.144E 06	0.212E 04	0.238E–02
106	LA41	0.136E 05	0.000E 00	0.000E 00
107	LA42	0.509E 04	0.000E 00	0.000E 00
108	LA43	0.114E 04	0.000E 00	0.000E 00

NUMBER	ISOTOPE	HALF-LIFE (SEC.)	CURIES AFTER 90 DAY DECAY	RATIO TO TOTAL
109	CE41	0.276E 07	0.332E 05	0.372E–01
110	CE43	0.118E 06	0.466E–14	0.523E–20
111	CE44	0.246E 08	0.150E 06	0.169E 00
112	CE45	0.180E 03	0.000E 00	0.000E 00
113	CE46	0.840E 03	0.000E 00	0.000E 00
114	PR43	0.120E 07	0.289E 04	0.324E–02
115	PR44	0.105E 04	0.151E 06	0.169E 00
116	PR45	0.215E 05	0.000E 00	0.000E 00
117	PR46	0.144E 04	0.000E 00	0.000E 00
118	ND47	0.100E 07	0.384E 03	0.431E–03
119	ND49	0.719E 04	0.000E 00	0.000E 00
120	ND51	0.900E 03	0.000E 00	0.000E 00
121	PM47	0.794E 08	0.239E 05	0.369E–01
122	PM49	0.194E 06	0.362E–07	0.405E–13
123	PM51	0.100E 06	0.965E–19	0.108E–24
124	SM51	0.230E 10	0.114E 02	0.128E–04
125	SM53	0.169E 06	0.859E–10	0.963E–16

TOTAL = 0.8923E 06

QUESTION IV.8

What impact would the chemical compounds described above, in the quantities which will be present in each container, have on the environment, including human beings, if they escaped from the container by accident, sabotage, or other means?

ANSWER IV.8

Not applicable.

QUESTION IV.9

What impact would the radioactivity described above, in the quantities which will be present in each container, have on the environment, including human beings, if they escaped from the container by accident, sabotage, or other means?

ANSWER IV.9

It is difficult to envision an act that would permit the escape of radioactivity from a cask. The casks themselves are rugged pieces of equipment. Casks must be designed to withstand a 30-foot free-fall drop onto any unyielding surface and a fire of 1475°F for 30 minutes without loss of contents. In the case of spent fuel, even if the cask is breached, the fuel cladding must also fail to have any release. If this were to occur, the small fraction of iodines, xenons and kryptons contained in the fuel pellet gap, would escape to the surroundings. The major constituent of any postulated release would be krypton-85 and its release would be far less than the 100 curie limit allowed in the DOT regulation.* Release of this amount of activity should result in no measurable impact on this environment. The activity in the resin shipments is chemically bound to the resin particles so that release of the resins will not cause dispersal of the activity. Cleanup of this material might be tedious but would not be hazardous to the environment.

QUESTION IV.10

Answer the previous two questions with respect to the quantities of chemicals and radioactivity which will be present in a typical *shipment* of waste material — by truck or train, or both, if both are to be used.

ANSWER IV.10

Refer to the response to Question IV.8 and IV.9 above as each *shipment* will consist of only one *container* (cask).

QUESTION IV.11

By what route or routes will containers of waste materials be taken from the Vermont Yankee plant to the re-

*Tariff No. 23, Hazardous Materials Regulations of the Department of Transportation, section 173.389(c)(1)(ii). [*This footnote in original*]

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processing plant or disposal site, whichever applies? Designate:

a.) The roads which will be used, by route numbers;

b.) The cities through which the containers will pass;

c.) The number of stops expected and the places where they are expected to be made;

d.) The train tracks which will be used, if any, specifying clearly where they are.

ANSWER IV.11

Vermont Yankee does not know the travel routes to be used.

QUESTION IV.12

What, if any, calculations or studies have been done to determine the chances of an accident involving waste-carrying trucks or trains from the Vermont Yankee plant over the course of its useful life? If such calculations or studies have been made, supply them and indicate their conclusions.

ANSWER IV.12

No accident studies have been made for Vermont Yankee.

QUESTION IV.13

What, if any, studies have been done to learn the chances that a waste container might burst open in the event of a collision or accident involving a truck or train transporting the wastes?

ANSWER IV.13

Vermont Yankee knows of no specific studies performed to evaluate the probability of damage to a shipping container in transit.

QUESTION IV.14

Have any of these tests been conducted under conditions approximating actual conditions — involving dropping containers from moving trucks or trains, for example — as opposed to testing with standard laboratory bursting and puncture tests? Supply copies and summarize results.

ANSWER IV.14

Vermont Yankee knows of no tests being performed with full-sized containers under real accident conditions.

QUESTION IV.15

What, if any, calculations or studies have been done to determine the liklihood of attempted sabotage or hijacking of a truck or train carrying waste from Vermont Yankee during the useful life of the plant? If such studies have been done, supply them and indicate their conclusions.

ANSWER IV.15

Vermont Yankee knows of no studies that have been performed in this area.

QUESTION IV.16

Is it possible to obtain a critical mass with any isotope or isotopes or combination of isotopes and other materials which will routinely be present in the high level waste shipments being shipped from Vermont Yankee Nuclear plant? If so, specify all such isotopes and/or combinations of isotopes and other materials.

ANSWER IV.16

Reactor fuel is used until it no longer is capable of producing a critical mass. Once the fuel is removed from the reactor and allowed to decay for 90 days, it may be possible to obtain a critical mass with fuel and water at room tem-

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perature. As mentioned in response to Question V.17, it would require four fresh fuel assemblies arranged closely in water to obtain a critical mass; the number of spent assemblies to obtain a critical mass is dependent upon burnup. No calculations have been made, but an estimate would be at least six spent assemblies closely arranged in water would be required. The isotopes involved are those of uranium and plutonium.

QUESTION IV.17

If the answer to any part of Question 16 is yes, how many containers of high level wastes would be required to obtain enough material to obtain a critical mass?

ANSWER IV.17

The number of containers (casks) is dependent upon the size of the container. One large rail cask would contain a sufficient number of assemblies. The truck cask might contain a sufficient number of spent fuel assemblies, but its exact size (and hence capacity) is not known at this time.

QUESTION IV.18

If the answer to any part of Question 16 is yes, is a theft of enough waste material to produce a critical mass a credible possibility? If the answer is no, explain in detail why not, including information as to precautions to be taken to prevent such a theft. Supply studies relied upon.

ANSWER IV.18

No. Vermont Yankee considers that the attendent problems associated with the handling of spent reactor fuel removes this act from the relm of credibility.

QUESTION IV.19

What is the approximate value, in dollars, in America, of the radioactive material which will be contained in each con-

tainer of high level waste materials? On the international market?

ANSWER IV.19

As mentioned in previous responses, the number of fuel assemblies in each shipment is not known at this time, but is estimated to be between 6 and 20, dependent upon truck or rail cask utilization. At present, the only radio-isotopes of value are those of uranium and plutonium, which are fissile. The spent fuel is considered worthless until reprocessed. The following prices are for the fissile materials present in one spent assembly after separation but does not include the cost of reprocessing.

Fissile Element	American Market	International Market
Plutonium	$7,000	$10,000
Uranium	$8,000	<$ 8,000

QUESTION IV.20

What, if any, calculations or studies have been made of the expected future loss of radioactive material, as a percentage of the total transported, over the useful life of the plant? Supply the study, or studies, and its/their conclusion(s).

ANSWER IV.20

No calculations or studies have been made.

QUESTION IV.21

If such calculations have been made, how much of this "lost" material is expected to be disseminated into the environment? What is the basis for this estimate, if any? Supply the relevant study or studies.

ANSWER IV.21

Not applicable.

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QUESTION IV.22

What would be the effect on the environment, including human beings, of the dissemination of this material into the environment? Supply relevant studies, if any, and their conclusions.

ANSWER IV.22

Not applicable.

IV. DISPOSAL OF HIGH LEVEL WASTES

QUESTION IV.(DIS)*.1

Where will high level radioactive wastes from the Vermont Yankee plant be disposed of? If the site or method of disposal is expected to change during the useful life of the plant, specify with respect to each expected site or method and period.

ANSWER IV.(DIS).1

Refer to the response to Question I.7 for the spent fuel. The other wastes will go to a federally licensed disposal site, which is responsible for ultimate disposal.

QUESTION IV.(DIS).2

What is the total volume and mass of the high level waste materials to be shipped from the plant over its useful life?

ANSWER IV.(DIS).2

The total volume will be approximately 10,000[1] cubic feet and weigh approximately 3,750,000[2] pounds. Refer to Sec-

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Section IV. [*This note in original*]

*DISPOSAL OF HIGH LEVEL WASTES. [*This note in original*]

[1] This is an error in the original and should read *"3,500"* instead of "10,000". See *supra* at A-45.

[2] This is an error in the original and should read *"1,800,000"* instead of "3,750,000". See *supra* at A-45.

tions II.A, III.A and IV of the Supplementary Information for details.

QUESTION IV.(DIS).3

What is the total amount of radioactivity (in appropriate units of radioactivity) with a half-life over 20 years which will be produced at the plant over its useful life?

ANSWER IV.(DIS).3

Assuming that the reactor core will be replaced an equivalent of 7½ times over the 30-year lifetime of the plant, the following quantities of fission products with the half-lives greater than 20 years will be produced.

Isotope	30-year Total (Ci)
I-129	1.19×10^1
Sr-90	4.00×10^7
Cs-137	3.98×10^7
Sm-151	3.03×10^4

In addition to the above, it is estimated that 1.3×10^5 curies of uranium and plutonium will be present in all the spent fuel used in this period.

QUESTION IV.(DIS).4

What physical state will these wastes be in when they are disposed of?

ANSWER IV.(DIS).4

Refer to Supplementary Information sections II and III.

QUESTION IV.(DIS).5

If it is intended that at some time during the life of the Vermont Yankee plant the high level wastes are to be disposed of in solid form, when is it expected that this process will be in operation?

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ANSWER IV.(DIS).5

Refer to Answer IV.(DIS).4.

QUESTION IV.(DIS).6

If the wastes are expected to be solidified at some point during the useful life of the plant?

a.) Describe the process by which the wastes are to be solidified.

b.) Describe the chemical composition of the solid to be manufactured.

c.) Describe the physical properties of the solid to be manufactured, including, but not limited to, its melting temperature, rate of expension with temperature, and resistence to destruction from forces applied to it gradually and suddenly.

ANSWER IV.(DIS).6

Refer to Answer IV.(DIS).4.

Vermont Yankee does not anticipate changing the state of the wastes (as described in Supplementary Information sections II and III) during the useful life of the plant.

QUESTION IV.(DIS).7

If the wastes are to be disposed of in liquid form at some time during the life of the plant:

a.) Describe the physical, chemical, and radiological characteristics of the liquid.

b.) Describe the method of disposal (e.g., in tanks, injection into bedrock, etc.) to be used for the material.

ANSWER IV.(DIS).7

As far as Vermont Yankee knows, no high level wastes are disposed of in liquid form, nor is it proposed for the

future. All high level wastes are solids or fixed in some manner prior to ultimate disposal.

QUESTION IV.(DIS).8

Answer the following questions with respect to disposal of both liquid and solid form high level wastes if both methods are to be used during the life of the plant; if both methods are not to be used, answer with respect only to the method to be used:

a.) Describe the containers into which the waste matter is put for disposal. Specify:

1.) the size of the container;

2.) the amount of waste material to be contained in each container, by weight, volume, and amount of radioactivity (using appropriate units of measurement);

3.) any shielding for protection from radioactivity which is built into the container;

4.) any devices or construction designed to control or dissipate heat from the waste material;

5.) any devices or construction designed to resist outside or inside pressure on the container;

6.) any devices or construction designed to prevent the release of the radioactive material to its immediate environment.

b.) Describe the facilities for storage of the containers for radioactive wastes.

c.) Describe the procedures for assuring that no radioactive wastes from these containers will escape into the environment at the site of the disposal facility.

d.) At what date in the future is it expected that these wastes will be harmless to human beings and other life?

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e.) At what date in the future is it expected that security measures will no longer be needed to prevent human or other life from being endangered by the stored wastes?

f.) What studies, if any, have been made to determine how human and other life will be prevented from being endangered by these wastes during the period they are not harmless to life? Supply these studies, if any, and give their conclusions.

g.) With respect to the foregoing estimates, give estimates of the impact of each of these releases on the environment, including human life. Describe the probable route(s) through which such escaping materials would enter the environment, and through which they would travel. Supply any relevant studies upon which any conclusions are based.

h.) What strategies, if any, have been formulated to recapture any material escaping from the storage facility? Describe and supply relevant documents.

i.) How, if at all, can the storage facility be repaired should it become sufficiently impaired to release radioactive material? Describe and supply relevant documents.

ANSWER IV.(DIS).8

We are advised by legal council that in view of the Boards findings, no answer is required.

QUESTION IV.(DIS).9

What plans have been made for disposal of the highly contaminated structures associated with the reactor facility

at the end of its useful life? Describe and supply relevant documents.

ANSWER IV.(DIS).9

No plans have been made.

QUESTION IV.(DIS).10

What plans have been made for preventing damage to the environment, including human life, from the radioactive structures remaining on the site of the reactor at the end of its useful life? Describe and supply relevant documents.

ANSWER IV.(DIS).10

No plans have been made.

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UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

IN THE MATTER OF	DOCKET
VERMONT YANKEE NUCLEAR POWER CORPORATION	No. 50-271
(VERMONT YANKEE NUCLEAR POWER STATION)	

ORDER DENYING MOTION OF INTERVENOR NATURAL RESOURCES DEFENSE COUNCIL, INC. RESPECTING PREPARATION OF A NEW DETAILED STATEMENT OF ENVIRONMENTAL CONSIDERATIONS AND FOR REHEARING OF ORDER ON INTERROGATORIES

At the prehearing conference in this proceeding held on June 22, 1971, Intervenor Natural Resources Defense Council, Inc., filed a motion to require the preparation of a new detailed statement of environmental considerations and for a rehearing of Atomic Safety and Licensing Board's rulings with respect to contested interrogatories. Oral argument[1] was had respecting the motion which appears to be primarily directed to the environmental impact of nuclear waste material transportation, reprocessing and disposal. Movant contends that since a nuclear plant operation will produce nuclear waste material, the entire sequence of events following that production of waste material is within the scope of the issues assigned to the Atomic Safety and Licensing Board for determination. Movant contends that the National Environmental Policy Act (NEPA) requires that this issue be included in this proceeding and that

[1] Later, and on July 7, 1971, a brief by New England Coalition on Nuclear Pollution was filed in further support of the motion.

the detailed environmental statement, required by that Act, reflect these considerations.

At the oral argument, the Board noted that separate licensing procedures are prescribed by the Commission for the consideration of authority to undertake nuclear waste material transportation as well as separate procedures for reprocessing and disposal. The separate procedures imply different issues than would be pertinent for nuclear power plant operation.

The scope and effect of an environmental statement required by NEPA in relation to procedures provided by the Atomic Energy Commission, particularly Appendix D to 10 CFR Part 50 of the Commission's Regulations, are under consideration in the United States Court of Appeals, District of Columbia Circuit *In the Matter of Calvert Cliffs Coordinating Committee v. Atomic Energy Commission* (Case 24,871). This Atomic Safety and Licensing Board believes that it would not be in harmony with the quasi-judicial system to render a ruling granting the motion here involved while that Court decisional activity is underway. (See *California v. Federal Power Commission*, 369 U. S. 482 (1961).)

Insofar as the motion herein seeks a reconsideration of Board rulings concerning "certain interrogatories" to which objections were sustained by Order of the Board on May 11, 1971, it is the opinion of the Board that no additional facts have been asserted nor any different law advocated to warrant any different ruling than as shown in the Order of May 11, 1971, nor has adequate basis been shown to justify a certification of this motion to the Commission or to the Atomic Safety and Licensing Appeal Board.

WHEREFORE, in accordance with the Atomic Energy Act, as amended, and the Rules of Practice of the Commis-

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sion, IT IS ORDERED that the aforesaid motion of Natural Resources Defense Council, Inc. be and it is denied.

ATOMIC SAFETY AND
LICENSING BOARD

By SAMUEL W. JENSCH, *Chairman*

Issued:
July 20, 1971
Germantown, Maryland

UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

IN THE MATTER OF:
VERMONT YANKEE NUCLEAR POWER CORPORATION
(VERMONT YANKEE NUCLEAR STATION)

DOCKET No. 50-271

Vermont National Guard Armory
Brattleboro, Vermont
Thursday, October 21, 1971

Hearing in the above-entitled matter was reconvened, pursuant to adjournment, at 9:00 a.m.

BEFORE:

SAMUEL W. JENSCH, Esq., Chairman,
Atomic Safety and Licensing Board.
DR. DAVID HALL, Member.
DR. IRA ZARTMAN, Member.

APPEARANCES:

(As heretofore noted.)

[2149]

low power consideration includes environmental matters, in fact they receive serious consideration. So we do have a lot involved besides the mechanics and the hardware for November 29 for low power testing.

If other attorneys are prepared and ready, and will so indicate to Applicant, we can have the necessary witnesses here and the other attorneys can go forward. But I think all attorneys should be prepared to use the week in what-

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ever order is convenient to the attorneys. Because the Board finds it somewhat inconvenient to have fragmented hearings, but this is the best we can do.

Mr. Ayres, were you going to say something?

MR AYRES: Yes, I just wanted to ask one further question.

We have had so far no mention of the pending motion on waste disposal and transportation issue. I didn't know whether you wanted to bring that up. Basically I wanted to ask whether we could expect some kind of resolution of that between now and say the next session, so that we could prepare for the environmental session.

CHAIRMAN JENSCH: Let's give some consideration to that right now.

Have you received the so-called September letter from the Director of Regulation, which had included in the transmittal as I believe we discussed before, the unauthored, undated, and [2150] unsigned and without any reference to the Atomic Energy Commission, a statement that indicated the scope of matters for environmental statements?

In that transmittal it indicated that, as I understand Staff counsel the other day, that that does represent a Commission action. I wonder whether the Commission action has not thereby disposed of your motion as to which you may have objection and may want to preserve some record regarding it.

MR. AYRES: Mr. Chairman, maybe I am not clear on what you are saying, but we did submit an argument as a response to that, to the memo from the Staff, which included that September 1 unauthored memo. And it was our contention there that that was probably no sort of expression of

the Commission intention which should be given any credence, that it was made out well before the time when Appendix D was finally promulgated.

Given it was the impression of at least one of the groups that responded, namely, Vermont, that the Commission later expressed a different policy in a similarly informal way and given that in all of the formal expressions of position in Appendix D, the Commission appears to accept the position more like ours.

Now perhaps I am confused about what you are saying. Am I construing what you say as a ruling or not?

[2151]

CHAIRMAN JENSCH: No, I was inquiring for your discussion really. I wondered whether this item that was transmitted — it is dated September 1 — didn't dispose of the motion. I take it that it is your position that it does not because you say something transpired when Appendix D was issued on September 3, 1971 or was it September 9?

MR. AYRES: My position is that Appendix D is inconsistent with that letter. It seems also to me that that letter in itself is rendered less reliable by the counter-questions suggested by the State of Vermont, for example, in its response.

What I am saying is that what is at stake here is simply a question of authority.

Is it Appendix D that controls or some sort of very unclear, as to its legal status, memo, which was written before the Commission had come to a final conclusion, presumably therefore before the Commission had completely considered the question of what should be covered?

CHAIRMAN JENSCH: Can you refer to the particular part of the Appendix D to which you say overruled or

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presents a different view than the September 1 memoranda included in Harold Price's letter of September 3?

MR AYRES: Appendix D, in Section 1 I believe or Section A, quotes essentially the language of the National Environmental Policy Act.

[2152]

Yes, it is Section A, paragraphs la and be for example, in Appendix D.

[2153]

CHAIRMAN JENSCH: Will you read that, please, for the record?

MR. AYRES: I don't have it before me. Just a moment. Well, it says it is a discussion of what either the supplemental or original environmental impact statement should include, pursuant to Appendix D.

And it describes, under section A-1, paragraph (a) what should go into — as one of the elements of what should go into that, the environmental impact of the proposed action, and paragraph (b) says "Any adverse environmental effects which cannot be avoided should the proposal be implemented."

Now, standing on its own, their own, neither of those might be considered clear, except for the fact that in both areas what is described is either "any" adverse effects or "all" of the environmental impact.

I think the meaning of those phrases is a lot clearer by virtue of Calvert Cliffs. It seems to me Appendix D is a response to the Calvert Cliffs, and that this language is no more than restating what the court said when it said that environmental impact statement should include "any and all" adverse effects.

It has been our contention all along and it remains so that the issues we would like to present to the Board are included within the meaning of any and all adverse effects.

CHAIRMAN JENSCH: I think one of the problems that **[2154]**
the Board has discussed in reference to that matter is what is the nuclear reprocessing plant that would be pertinent to this proceeding, assuming we gave consideration to that phase of the transportation?

MR. AYRES: Mr. Chairman, I think that is one question that has to be answered. We have no description so far of which one that might be.

CHAIRMAN JENSCH: Well, I think —

MR. AYRES: For all I know, it may be the problems are very common, that the dangers involved to the environment in the reprocessing at one plant or another are similar enough so that the Board can evaluate them from knowing basically what dangers are involved in any reprocessing of this sort of material, as it is presently expected to be done.

CHAIRMAN JENSCH: It has been my understanding that there were several reprocessing sites within New York, Georgia, the State of Washington — I don't know what the status is with reference to the State of Kansas.

And in order to have something certain for meteorological considerations I presume we would have to, under your theory, consider all of those five locations and then maybe they wouldn't ship it there anyway.

MR. AYRES: Mr. Chairman, I think the Applicant could probably reduce the number of locations which might have to be considered. I might point out also that even within **[2155]** memorandum from the AEC that we were discussing a moment ago the Applicant's environmental re-

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port is required to describe the environmental effects from transportation of fuel elements from the fuel fabrication plant to the reactor, as well as the transportation of spent fuel elements from the reactor to the fuel reprocessing plant.

CHAIRMAN JENSCH: Yes.

[2156]

MR. AYRES: Now, if that description is required in the environmental report, even under this memorandum, then presumably the Applicant is going to have to tell us at any rate where that material is going to go.

CHAIRMAN JENSCH: Unless the transportation to any fuel reprocessing plant is the same as it would be to any other reprocessing plant, so that the problems are in common and alike, he may not be able to identify it, or select it — I don't know if they have selected the site or not.

MR. AYRES: Suppose one of the reprocessing sites was in Wyoming, and the other one was in South Carolina or New York. Presumably, the dangers involved are different, if only in quantity, merely by virtue of the greater distance involved.

Now, it may well be that the problems in reprocessing are more similar, even to each other, no matter which plant does the job, than the problems of transportation.

I think what the Commission has done, even in this memorandum, is to say they want the location and they want a description of the problems associated with it. And the same kind of reasoning would apply if you were talking about reprocessing plants, it seems to me.

DR. HALL: Does the Applicant have any knowledge about where the reprocessing plant is going to send this?

MR. AYRES: I have asked that question on **[2157]** interrogatories.

DR. HALL: Did you get an answer?

MR. AYRES: I received an answer, a choice of several, but it seems to me that maybe that question is one which the Applicant ought properly to answer.

DR. HALL: You have asked it, and you have gotten an answer to the interrogatory. Was it not specific?

MR. AYRES: No, it wasn't specific.

DR. HALL: My question is, do you have reason to believe the Applicant knows definitely that one particular site will be the recipient of the fuel processing plant's shipments?

MR. AYRES: No, I don't have reason to believe one way or the other at this point.

DR. HALL: Do you have any notion that in the future the Applicant will always be using the same fuel processor fuel reprocessor?

MR. AYRES: I don't know.

DR. HALL: May they not change from one to another, depending on the best contract terms available to them?

MR. AYRES: In that case, maybe what is involved is a description of the dangers in more than one place. It seems to me at least —

DR. HALL: So we go back to what the Chairman said, we have to look at the whole country, the future plans of all **[2158]** parts of the country. Is that right?

MR. AYRES: I don't know. That depends on what the Applicant tells us about what his plans are. That is at least one answer. The other is this —

DR. HALL: The thing that keeps getting me is I am sure the Applicant — I guess I could ask him — but I doubt

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the Applicant has any plans beyond the fuel processing. They want to get rid of the fuel element and buy new ones. But once he sells the fuel elements to the reprocessor, he loses control.

MR. AYRES: That may well be true. But it seems to me the fact that the Applicant himself would like not to be concerned with that question does not mean that it is not a relevant question to be asked before this Board when dealing with the environmental impact of the plant. It may be that the information sought will have to come partly from the Applicant and partly from the Commission.

DR. HALL: I think the Commission doesn't know this, either. They have licensing procedures for processing plants. It seems to me analogous to the fact that I put my garbage can on the street and I pay somebody to come along once a week to haul this material off. And this is basically the thing, that I deal with the vendor and the disposal man has to get a license from my community on where he takes the garbage. If somebody asked me, I wouldn't know where it went.

[2159]

MR. AYRES: I think that is a very accurate description or parallel case. In both cases, it seems to me the same thing applies. That is, if someone was asked, if this Board or some other Board were asked to describe and consider the environmental impact of your garbage or the operation of your household, put it that way, although you might say to them, "I put out my garbage and someone takes it away," that Board, it seems to me, would be required to look at where the garbage went.

DR. HALL: But then you have to get the garbageman in, which, in this case, is the fuel reprocessor.

MR. AYRES: It is also true that the garbageman has to get a license from the Atomic Energy Commission. We

are not dealing with the numbers of factors that we would be dealing with in that situation. Even in planning, I gather there are not a great number of disposal sites.

DR. HALL: But we are considering the license for this reactor from now for 40 years, which is the economic life of the plant, at least I assume that, and it seems to me you are asking us to crystal gaze into the future as to what will be the situation at that time.

MR. AYRES: I think to some extent the National Environmental Policy Act does ask you to do that, although I think it certainly is willing to make some compromise on practicality. It seems to me the Board's duty would be
[2160]
probably to look at as clear a picture as it can get now of what is expected to be done with these wastes.

DR. HALL: In spite of what Justice Wright wrote, it seems impossible to look in the future and if you ask me, we just have to extrapolate.

MR. AYRES: Dr. Hall, we are extrapolating a lot of factors in this proceeding. It seems to me you may be forced to extrapolate and do the best you can.

DR. HALL: Extrapolation of those things which are extrapolatable is proper, but to say where is not. The amount, yes, the total volumes, yes, I think that can be forecast, assuming power growth.

MR. AYRES: Can't we also forecast, though, the general type of reprocessing mechanisms that are expected to be used now, general type of disposal process that is expected to be used now?

DR. HALL: I would not want to.

CHAIRMAN JENSCH: Did you receive a copy of a letter from Dr. Wilson, who has given a limited appearance

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statement in the proceeding and who later sent in a letter in reference to this waste disposal matter? I think there was intended to be general distribution by the public proceedings branch of this letter.

DR. HALL: It was included in the transcript.

MR. AYRES: Yes, I have seen it.

[2161]

CHAIRMAN JENSCH: The letter to which I refer is that wherein Dr. Wilson said, well, if there is anybody in the United States that doesn't want a reprocessed waste disposal location, that there were several places in England that I think he said would be interested in, places where they would be interested in having that. I wonder if we assumed that for a moment, that there were not any more places authorized for disposal in the United States, is it your thought we would go to England?

MR. AYRES: I don't know why you would have to go to England.

CHAIRMAN JENSCH: England or Canada.

MR. AYRES: I am not asking we go to Kansas, either.

CHAIRMAN JENSCH: Would you feel happier if you had an assurance that there would be a public hearing at the licensing proceeding for a waste disposal plant?

[2162]

MR. AYRES: No, Mr. Chairman, I wouldn't, and the reason is quite simple. What we are asking is that this plant be examined along with the other reactors that are being built now from the point of view of what it means as a complete system for producing power to the ecology and to possible future generations of human beings.

Now if we were to go to a hearing in Lyons, Kansas, or some other place in Kansas, or wherever it was, on the dis-

posal site, we would be able to examine there on the impact, environmental impact of that site.

But even if at the end of the hearing, the Licensing Board involved said well, this isn't the place to put it, it would not be empowered to say all right, you better shut down Vermont Yankee and all of the other plants, because we haven't got any place to put this waste, and we don't think it is a safe thing to put away.

In short what I said is the only Board that has an ability to judge this system as a whole is the one that is looking at this plant, which will produce the waste and therefore the Board which has the power to decide whether these wastes will be produced.

CHAIRMAN JENSCH: Isn't it something in the technical specifications that there can be only a certain amount of radioactivity stored on the site, which would automatically mean if there weren't some outlet for disposal, you would have [2163] to make some adjustments, so that they can't store in excess of a certain amount, they would have to ship it somewhere or stop? It isn't a question of whether a licensing board on reprocessing or waste disposal location would do about that, it would automatically apply to any plant.

But I thought you indicated, and I thought that is where you were going to start your development, that there is probably some limit on practcality. I think that really is the test.

I think the Staff used a little different language, but to the same effect. They said it gets so remote. For instance, let me ask you your view on this: Assuming a burst release of some radioactivity from the plant in the course of normal operations. That burst has measurements made

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regarding the level of radioactivity, they trace it out to a certain point, and they get to a point where, with all of the best evidence that is known, there is no exposure, no damage, no injury to any person or being or property or contamination of any foods and so on.

As to that, that is kind of the end line of any possible danger or concern. But there is still some radioactivity, it may be very minute.

Now doesn't that kind of a limit likewise apply here? There is a limit to where your interest goes, where you have to stop and let somebody else pick up the concern. For instance, **[2164]** it seems to me if I read this September 1 item, in the September 3 letter of Harold Price, they are trying to fix a limit of practicality. And they are saying you can have inquiry to the fullest extent about transportation, from the fuel fabricator to the reactor and from the reactor to a processing site of the spent fuel, or rather the package of radioactive waste to a waste disposal area. But they are trying to, within the realm of something that is reasonable, say, well, that is the extent of the control by the Applicant.

It seems to me that the responsibility for any activity depends on control . Once there is a loss of control, there is no fixation of responsibility.

MR. AYRES: I think we —

CHAIRMAN JENSCH: I think you can conceive of minute effects from radioactive bursts, a cloud going off to the moon. Maybe it will go that far, if it has anything in there that has a half life, I don't know how long it takes to get to the moon, but suppose it goes up to the moon.

Are we going to go up to the moon and find out, are we going to trace radioactivity to the moon?

MR. AYRES: I think we are talking about two different kinds of practicality. One of them is what I think the Staff was talking about when it used the notion of proximity. And what I think you were talking about when you described the situation where a burst of radioactivity goes out and we lose [2165] track of it, because we can no longer measure it, it becomes so small. At that point in both cases I think you do indeed consider it impractical to follow that effect any further. The reason is because it has become negligible. But that is not the same sort of situation that we are speaking of here. What we are speaking of here is a situation where there is nothing in the slightest bit remote about the likelihood that something is going to occur, namely, that the wastes will be taken to a reprocessing plant or a disposal site. We know all that, it is not remote in that sense.

CHAIRMAN JENSCH: But the control is gone.

MR. AYRES: That is true. The control is gone.

That is true. The control of the Applicant is indeed gone, but the control of the Board in passing judgment on the proprietary of granting an operating license is a different matter all together.

CHAIRMAN JENSCH: It must be related to the control that we can find this Applicant has over an activity that is sought to be licensed to be effective.

MR. AYRES: There is control in the starkest sense, you have it in the sense that you can decide to either license this plant or not to license the plant.

CHAIRMAN JENSCH: Is it your thought that we could issue an order to the Applicant and say now when you send this spent fuel to the waste processing plant at West Valley, New [2166] York, that when it comes out of

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there, you have to ship it to England? You better tell that West Valley, New York crowd that the Yankee stuff has got to go to England, we are certainly going to ship it back on the, whatever, what was the ship that came over a while ago with tea?

MR. AYRES: No, I don't think that is what I had in mind. What I have in mind is the only decision which is before you at the moment, which is whether or not to grant an operating license to this plant.

What I am asking is for the Board to consider, among the issues that it considers on that question, one issue, which is quite different from asking the Board to decide sub-issues like shall it require sending things to England.

[2167]

CHAIRMAN JENSCH: Well, the Board has considered this on several occasions, not only from the brief discussions which have been held and the briefs, which I might say we thank the parties for their briefing, I think the briefing on this subject has been very good.

I think it is a subject, that until this letter of September 3, which transmitted the item of September 1, was very clear. The Board is inclined to accept the September 1 transmittal, as sent with the September 3 letter, as representing the Commission action.

Now, even that might be open to some question, since it does not bear the imprints of an official Atomic Energy Commission document. I think the parties are entitled to that kind of an issuance.

MR. ROISMAN: Mr. Chairman, I wonder if I might speak to the subject for a moment?

CHAIRMAN JENSCH: Yes.

MR. ROISMAN: To begin with, the statement attached to the September 3 letter, this statement at its very best,

assuming it was promulgated under a regulation number and so forth, and we didn't have the procedural difficulties that I share with the Board, is as stated in the title, "A Statement of the Scope of the Applicant's Environmental Report with Respect to Transportation Lines and Accidents."

Now, I don't see anything in that document which **[2168]** says that the jurisdiction of this Board is narrowed in terms of the issues that it should cover. In fact it seems fairly logical to me.

The Applicant can't tell us the kind of information that needs to be known about the radioactivity releases at the reprocessing plants or the radioactivity releases at the waste disposal plant. The only thing that tells us what are the issues that this Board can consider is what is in Appendix D as it is written, or if there were a fuller description, which there is not, of exactly what the detailed environmental statement should have, which would be statement of what the Staff should consider in the proceeding.

What is in Appendix D seems to me to completely undercut the suggestions, and I couldn't agree more with the statement that was made by Mr. Ayres, that a quesation involving the disposal of radioactivity is properly here, despite the fact that the Commission does license reprocessing plants, and will at some time and has in some cases already licensed high level waste disposal sites.

In Appendix D, and I have the copy that was not in the Federal Register, but the one that was issued by the Commission in part A, paragraph eight, near the end of the paragraph, there is a discussion of what are the obligations with regard to radiological safety matters, which is what

we are talking about here. It says "While satisfying AEC standards [2169] and criteria pertaining to radiological effects will be necessary to meet the licensing requirements of the Atomic Energy Commission act, the cost-benefit analysis will, for the purposes of National Environmental Policies Act, consider the radiological effects together with the thermal effects and the other environmental effects of the facility."

I don't know of any other interpretation that can be placed on that sentence than to be saying that the fact that the wastes from this plant go first to a licensed reprocessing plant, and then a licensed disposal plant does not mean that the Board should not consider at this hearing the impact on the environment.

Now, let me be clear what I mean when I say impact on the environment, or in this case, the radiological effect of the waste disposal, taking the words from the Appendix D.

We know the site where the reprocessing or the fuel disposal is going to be or we don't. Let's take the case where we know where it is going to go. If we know where it is going to go, then we know what the impact on the environment is going to be of the additional waste produced by this plant. We know that this plant is going to add so many curies in the fuel, because we have estimates of how many curies will be in the fuel, to the reprocessing cycle and the reprocessing plant, we know how much that plant is designed to release, under design basis conditions, all parts of its licensing procedure and we [2170] can have in this record, in relatively simple form, easy statement of when you add another ten pounds or however these things are computed, of this radioactivity waste, how much release do you get. Now, that effect is not remote. That is not like

your example of sending a little tiny bit of radioactivity to the moon. We are talking about some radioactive materials that have lived for hundreds or thousands of years —

[2171]

CHAIRMAN JENSCH: May I interrupt.? That is just where I wanted to ask if you would expand on that. Is it your thought that we get into the effect of whatever these high level wastes are if they have a half life of a thousand years; are we going to speculate on the environmental impact of the thousand year half life isotope? And what would be the nature of society by that time?

You would think that somebody somewhere would have to draw a line. I don't know what is the most reasonable place out of several possibilities. But if, as Mr. Ayres says, I think his words were we may have to compromise on practicality. Somewhere, even if it seems like an arbitrary line, somewhere something has to be done. And it seems to me that may be done provided there are opportunities for hearing as to the other matters.

Now if you are going to take a half life of a thousand years, we have really got a hearing going here and I don't know whether we aregoing to make it.

MR. ROISMAN: Mr. Chairman, I don't find this at all humorous from the Applicant's side of the table, I find it a rather serious matter. You put your finger on the whole problem. That plant, if it turns on, will produce something that will be with this world long after we are gone. And the issue that the National Environmental Policy Act is directed to is how much do we mortgage the future for our benefit today.

[2172]

Now if we can't predict what is going to happen to that fuel, and those wastes a thousand years from now, then that

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is a factor to consider in the wisdom of creating a nuclear power plant. Nuclear power plants create wastes that don't go away very quickly. I am not saying to the Board that we must be able to say that little Jimmy Jones living a thousand years from now is going to have thyroid cancer because of the releases from the waste of this plant. I am saying if there is as much doubt about that question as the Board seems to feel there is, then that is an issue in deciding on the wisdom of licensing this plant. We already have a dirty river out there because nobody thought about that when they put the Barrows Coal Company up, when they put those other plants up up the river. And the National Environmental Policy Act was passed almost two years ago for the specific purpose of saying, stop it, start thinking about what you are going to be doing in the future. And the doubts are part of the environmental analysis.

If we don't have the answer, that is not to say we have to spend 16 months of hearings trying to get it. Let the Applicants say they don't know what it is going to be, they know the radioactivity is high, they know if anybody walked into the room where the waste was, and was exposed to it, unless it was a different kind of human being, they would be killed or seriously affected by the waste and then let's make a **[2173]** rational judgment about whether or not we want that kind of material around a thousand years from now.

The whole purpose of the Kansas site study was an attempt to predict how reliably you could put wastes in the ground in 1971 and be sure they would still be there, safe and sound, without any contact with human beings at the time that the waste's danger level was gone.

Now we were talking about the question of the remoteness of the imapct. You are talking about an entirely dif-

ferent matter. You are saying there is a lot of doubt. If we had that same doubt about the performance of the emergency core cooling system in this plant, a scant 20 years from now, this Board would be bound to say there is too much doubt about radiological safety, we don't know what will happen if there is a loss-of-coolant accident, it is in the future, we do have to speculate, we don't have enough evidence on it, license denied.

Now until the National Environmental Policy Act was passed, there was at least an issue as to whether or not we had to consider the waste question.

Now the issue is gone. It was gone on January 1 of 1970, and what Judge Wright said on July 23, 1971, was only what Congress said some 15 or 18 months before that.

DR. HALL: I disagree.

May I interrupt your eloquent and passionate speech [2174] for the press but —

MR. ROISMAN: Excuse me, Dr. Hall, but that speech had nothing to do with the press. And if it would make you feel beter, I will ask the press to leave. It had to do with this Board's responsibility and I resent the implication of your statement, Dr. Hall.

DR. HALL: All right, I withdraw the implications and I apologize for any inference I made.

I am aware you were speaking to the Board. But let me say I think you are speaking in the wrong forum, that the Board has no jurisdiction in this in my opinion. I am not trying to draw a legal conclusion. I am just saying that the Congress has passed the Atomic Energy Act of 1954, I understand that this is a question that you or some of your colleagues, somebody I read in the press, is challenging, the validity of a portion of the Atomic Energy Act, and of course that is not my concern.

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But in all of the problems associated with producing power by nuclear energy have been brought to Congress from time to time and the Joint Committee of Congress has considered these, and is fully aware of the problems. And the notion that the waste is a necessary concurrent or necessary part of the generation of power by nuclear energy is well known to Congress. There has been no move by Congress to pass any law saying that they shall not be used for generation of nuclear energy.

[2175]

To say that NEPA has changed this, the passage of the National Environmental Policy Act has changed this, I think is incorrect.

MR. ROISMAN: But, Dr. Hall, the point is this: We are trying to decide whether this power plant should be licensed.

Now there is going to have to be an analysis of its benefits against its costs. I don't disagree with you that as long as Congress keeps the 1954 Atomic Energy Act as written, that Congress has said as far as we are concerned, there is a point at which the benefits from nuclear power plants would seem to outweigh the disadvantages. But the question is, is Vermont Yankee at that point, or did it fall under the line or over the line? That is why we do a licensing proceeding for an individual plant. We can't get at the wisdom of the Vermont Yankee Plant if we can't at least weigh in the balance all of its reasonably predictable impacts on the environment. Or to be able to put in there that as to some impacts, we know that they will happen, but we can't really say where or when.

All right, that is a factor. You factor that in. Just as you factor in your doubts about the emergency core cooling system in deciding whether or not to approve a plant.

DR. HALL: My problem is then that if you ask, if that were the approach that thisBoard would have to take, I
[2176]
would have to say that I can't foresee all of this so I couldn't license any reactor. And that to me is close to defeating the will of Congress.

It is to the contempt of Congress, but it is certainly defeating the will of Congress.

[2177]
MR. ROISMAN: I think the problem is that you — I can understand why this would happen — but that you are seeing it in the context of the nuclear industry, rather than in the context of this nuclear plant. It may be that what we do here will have an impact on the nuclear industry, but what we are concerned with —

DR. HALL: That doesn't bother me.

MR. ROISMAN: — is this plant. And my concern is, to take the example to perhaps a situation we would never reach in this rather fuzzy cost benefit analysis, if you had weighed all of the benefits of this nuclear power plant, and you weighed all of the costs, environmental, monetary, and so forth, with waste disposal held aside, and you came out just about even, 50/50, maybe 50.1 in favor and 49.9 against, that you would have to factor in this additional cost, the fact that the plant was going to produce a waste product which would require very careful handling in the reprocessing part, and very careful storage in the waste disposal part.

And then if it had a risk to the public health and safety, as it went through those two steps, you might turn the balance the other way. Another plant in which the benefits outweighed the costs by 90 to 1 or something, it might be when you added in the incremental dangers associated with

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the processing and storage of fuel, you would still come up with an answer, yes, the plants should be licensed.

[2178]

I am not saying there is a legal requirement, at least not inherent, that the very fact that we don't know what will be happening to the long-lifed isotopes 1,000 years from now, or where they might be, means inherently that the Board can't license the plant. I think it certainly means that the benefits from the plant are going to have to be very high before we pay that price. But that is an issue that the Board can grapple with. It doesn't seem to me to be the kind of overly-expansive issue that you were discussing at all.

I think it is a relatively narrow kind of issue. The Applicant can give a lot of "I don't knows," and the Board can weigh the "I don't knows" in the process of deciding whether to license the plant.

DR. HALL: I don't know how to put the "I don't knows" into the balancing, so I am afraid what would have to result here would be a total investigation of present reprocessing plants, future plans for reprocessing plants, as well as the disposal plants. I think the mechanism, as far as I can understand the guidance, what we are asked to look at, is the mechanism for transportation of spent fuel elements, not to rule or to pass that these will go to a specific location.

And I think the narrowing of this issue to what towns this goes to, what highways, is also foolish inasmuch as we have no knowledge of the road situation **[2179]** in the future, even what the towns will be then. We can't do it in that narrow and detailed scope. I think the only thing we can do is try to see that there are reasonable procedures, techniques for moving the fuel from this plant to a place where a reprocessing plant might be. I can't see that the

Applicant can be controlling beyond that point. If we have to say that we consider the other, then the scope of this hearing is enlarged, so that I think it just breaks of its own weight.

MR. ROISMAN: But the inability of the Applicant to discuss it, that was exactly my point about the statement that came out in the September 3 letter, I can see a reasonable basis for saying that the Applicant can't do that. But the Regulatory Staff will be the sponsor of the ultimate environmental document that is introduced in this proceeding, namely, the detailed environmental statement.

And what we are talking about is what is the scope of that statement and then what is the scope of this Board's reviewing powers with regard to that statement?

DR. HALL: The Regulatory Staff just is the agency that determines or tries to investigate whether or not the procedures are within the rules and regulations of the Atomic Energy Act and the Code of Federal Regulations. They, I am sure, have no more idea than anybody else about the future status of the reprocessing plant in this country, where they **[2180]** are or will be or who will be operating them or where they are going to send their waste.

MR. ROISMAN: We have in this proceeding already a lot of predictions on things that seem to me to have no greater doubt. The Applicant is going to tell us about the integrity of the fuel rods. We don't know that they will keep buying from that manufacturer. They are going to discuss the questions of the reliability of their inspection system, that have to last through probably people who are not even here today and who are conceivably not even born, if we are talking about 40 years.

Their financial qualifications are based on a prediction of what happens for 40 years. The whole hearing is geared

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to a prediction. We all recognize we can predict much more easily what will happen tomorrow than we can what will happen next year and we live with that and make our judgments based upon the fact that some things are more easily known than others.

But if I understand what you are saying, Dr. Hall, you are suggesting that there may be a legal impediment to compliance with what might well be, as I think, the literal range of the National Environmental Policy Act. I would like to direct your attention to Section 103 of the National Environmental Policy Act, which imposed upon the Atomic Energy Commission, as well as all other federal agencies —

[2181]

DR HALL: It was not just the Atomic Energy Commission?

MR. ROISMAN: No, on all federal agencies, an obligation to advise the President on or before, I believe June or July 1, 1971, if there was any impediment in their statutes which would prevent them from full compliance with the Act. The Commission, as early as November last year, advised the President of the United States that there was no such impediment. And it seems to me that it is not open to now come forward as an argument that can validly be adopted by this Board that there is a legal impediment, that because of the way the Atomic Energy Commission Act is written, it would prevent this Board from fully exploring an issue which NEPA clearly requires it to explore.

[2182]

MR. ROISMAN: Mr. Chairman, may I just say one last thing? That is that it seems to me that this is almost the classic kind of question which if the Board feels it wants to decide ought to be referred to the Commission and I say the Commission rather than the Atomic Safety and Licens-

ing Appeal Board, I know one has been established for this proceeding, but we do have the problem of whether or not what Mr. Price sent out represented the position of the Commission. It is signed in his capacity as Director of Regulation.

We are trying to interpret a document, when we think of Appendix D, that was just written by the Commission. It seems to me that sending it to another group of men who themselves would have to speculate on what the Commission might have meant, could only lead us down the road where there would be a lot of doubt.

I would urge the Board to, if it wishes to consider the question of certification, to certify it to the Commission itself.

DR. HALL: In a sense, Mr. Roisman, you are making a challenge to the regulations, are you not?

MR. AYRES: Let me answer that, because I think it properly comes from me anyway. I think the answer to that is no. Quite the opposite. We are asking that the regulations be interpreted so as to preclude that. It is perfectly possible for the Board to make a decision without making any sort of [2183] challenge to the regulations on this.

CHAIRMAN JENSCH: Does anybody else desire to speak to this matter?

MR. MC GREGOR: Yes, Mr. Chairman.

The interest of the Commonwealth in this particular matter centers around the transportation of fuel to nuclear plants and the waste from nuclear plants through the Commonwealth of Massachusetts. The Commonwealth has regulations which require notice of such transportation and for that reason the Commonwealth is interested in the issue that has been raised by Mr. Ayres' motion.

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We would also like ot offer, for what the Board may wish to do with it, our advice as lawyers regarding the issue of what NEPA and what the regulations require.

CHAIRMAN JENSCH: We would be happy to have your statement.

MR. MC GREGOR: A fuller statement of our advice appears in a letter that we wrote in response to your telegram which invited our comments on this very issue. I would like to point out though in light of the discussion that we have had today that the issue is not a question of holding Vermont Yankee responsible in terms of physical control of what the plant puts out, but rather something I don't think any of us would quarrel with, that Vermont Yankee is responsible for the effects of its operation.

[2184]

On the issue of control, I would like to point out just as Mr. Roisman and Mr. Ayres pointed out, that we are going to be considering predictions on various other matters; that the Commonwealth is going to be very interested in looking at where the liquid effluent from the plant goes when it does go into the Connecticut River and what its effects will be, wherever they may occur even though there is that loss of physical control, once the effluent is placed into the river.

I think the analogy is a good one, and even though there may be more difficult decisions to be made as to nuclear waste, the analogy holds, and the Board is the one to make that decision.

The other licensing proceedings that have been mentioned are ones which consider how to handle nuclear waste once it is generated and they have not considered and will not consider whether the waste should be generated in the first instance. And I think this Board is appropriate to fit into

its calculus the incremental harm that will come from the nuclear waste from this plant.

I don't think the decision is as difficult as many would have it seem, because ultimately NEPA and the Commission's regulations do not require the impossible. We are men sitting here, you are men sitting on the Board and can only do your best to predict what effects there will be from nuclear waste. And [2185] what will fit into the calculus will be whatever however detailed your prediction may be, or if you cannot make a prediction, the fact that you have a level of doubt will the factor that is fit into the calculus of your decision.

I think it is important that someone in our governmental structure begins to make these ultimate decisions and because we find it burdensome or at times of difficult practicality to use our present sometimes cumbersome procedures in making these decisions is no reason for us not to try.

DR. HALL: I just wanted to respond briefly, partly to continue the discussion with Mr. Roisman.

It seems to me that the wastes thatcome from the reprocessing of the fuel taken from this reactor can be demonstrated to present a relatively minor problem. I won't, I am not testifying in this case of course, but let me just make that statement as an assumption and harken back to the time when there were very few reactors in this country, such as the time of Shippingport and Dresden 1, in which the reprocessing was not a problem. The problem that I agree with all of you is when we have a large number of reactors and we have many, many kilowatts. But still relating to this licensing here, the problem of this reactor is not the thing that is going to cause the problem for this country, it is the aggregate that is going to cause a problem

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for this country. And how that fits into this licensing proceeding, I don't see.

[2186]

MR. AYRES: Well, one sort of answer to that I think is that we have no forum in which to discuss the problem in the aggregate.

DR. HALL: I agree with you.

MR. AYRES: And therefore the only way we can consider it is at this proceeding and similar proceedings, at least in our mind.

Secondly, I think what we are really asking is that the Applicant and the Staff, if necessary, tell us how large the danger is from a given plant, this one. To say that the problem is one of the aggregate of a number of plants, perhaps a thousand or 1,500 plants in the next forty years, whatever the projections are, only tells us that the danger from the aggregate is about a thousand or 1,500 times as high as it is from a given plant, assuming they are the same size.

DR. HALL: It may be more than that.

MR. AYRES: Certainly. But what I am saying is there is some expressable relationship between the two. You can talk about the waste from this plant, the dangers involved in this, and rather than assume an answer, it seems to me the thing to do is ask them what those dangers are.

[2187]

CHAIRMAN JENSCH: Does anybody else desire to speak to this matter? The Board hears no such suggestion. The Board shares many of the concerns that have been expressed by the parties here. It is not a clear line. The Board, as I indicated, is inclined to accept this September 1 statement as reflecting Commission action at that time.

Whether Appendix D, which was issued on September 9, modifies that, is not clear, except insofar as the language used is considered, including all environmental impact.

The Board believes this matter should have Commission determination, that Atomic Safety and Licensing Board needs further guidance from the Commission. This is a major policy determination. It affects not only this plant, but it affects the licensing process. It is the view of the Board that this Board should not attempt to prescribe the policy matter, the Commission must do it. The procedure for this, however, is not quite so certain. There are two general methods. One is by certification and the other is by appeal.

In order to, in a sense, move this along, with the burden on the parties to carry the initiative, the Board is inclined to make a ruling and refer the ruling under the procedures for appeal. The Board will permit an interlocutory appeal in this regard, in order that the parties can then determine the precise issue that they present **[2188]** and so that the Board can secure a forum for the determination.

The referral procedure was utilized in the Duke Power Company construction permit proceeding and a determination was made following that referral. The Board believes that insofar as there is any specificity and guidance, it comes from this September 1 document which is not too clear to us; it is not a document that I think is in a form that it is certain that it represents Commission action.

I think the Commission action, an official document as the Commission has done, should be signed by the Atomic Energy Commission and it is stated to be by action of the Commission and it bears the attestation of the Secretary of the Atomic Energy Commission, as an official action of

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the Atomic Energy Commission. This document does not have that imprint. But we will accept it for the purposes of our ruling, but indicate our doubt about it by allowing the interlocutory appeal and referral to the Commission as the regulations provide.

The Board, therefore, denies the motion of the National Resources Defense Council and the associated parties in reference to it, to consider the aspects of transportation of high-level radioactive wastes from the fuel reprocessing plant, and the storage of the low level wastes at whatever location. The parties will better be able to activate the
?189]
procedures for appeal and consideration, we believe, and, therefore, the Board will allow the interlocutory appeal.

MR. WALLIG: Mr. Chairman, one matter of procedure. Since the Commission established an Appeal Board for this proceeding, Section 2.785(D) of the Commission's Rules provide that in those proceedings where the Appeal Board has been set, that the actions formerly performed by the Commission under Section 2.730, which is the section in which referral of a ruling of the Board is set forth, will be exercised by the Appeal Board.

Accordingly, I believe the proper procedure will be to the Appeal Board. The Appeal Board also has a right to certify a question on its own to the Commission, but under the rules, which we are bound by, there is no direct right to have an appeal or certification or referral to the Commission when there is an Appeal Board.

CHAIRMAN JENSCH: Yes, I think the problem is as to what is normally considered by the Commission. I think that may open up the realm of possible Commission action on the appeal, because this involves a new regulation, Appendix D, issued September 9, 1971, under a new statute

which Congress enacted, the Environmental Policy Act, and it has been the impression of the Board that the Atomic Energy Commission, certainly at the outset, will make all decisions in reference to the scope of activity to be conducted in its name [2190] respecting national environmental policy matters.

And this does involve an interpretation of the scope of the regulations that the Commission has issued. And while it may not be a challenge to the Commission, it certainly is an appeal to the Commission on its own regulation and, of course, the Atomic Safety and Licensing Board did not issue the regulation.

MR. AYRES: Mr. Chairman, one clarifying point. Your description of the issues a few moments ago was somewhat different from the description of the issues in our motion. I assume that you meant to cover all of the issues that we raised essentially in your statement.

CHAIRMAN JENSCH: Yes. That is why the Atomic Safety and Licensing Board here feels that the precise statement of the issue can better be presented by the parties, so that the matter will truly be before the Reviewing Board, whether it is the Atomic Energy Commission or the Atomic Safety and Licensing Appeal Board.

The mark of delineation between those two is not clear to us for this type of transaction.

MR. AYRES: I wonder also if you will be giving us a written opinion or order?

CHAIRMAN JENSCH: No. You may accept the statement in the transcript and use it as a basis for your action.

MR. ROISMAN: Mr. Chairman, another point —

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[2191]

CHAIRMAN JENSCH: We can, however, and I think we did in the Duke Power case issue a formal order. But I think it may be more delaying than helpful. The referral of the ruling is in accordance with the rules of the Commission, as Staff Counsel identified.

MR. ROISMAN: Mr. Chairman, just so we will know for filing purposes, will the Board be referring to the Commission, so there will not be a necessity to refile, the various motions and responses that have dealt with this question? I don't know; there is nothing in the regulation —

CHAIRMAN JENSCH: I think that is a matter you folks will have to decide, because I think the procedures, once the referral is made, it will have to be determined by the parties. If they feel a better presentation can be by incorporating all of these things, maybe they would be inclined to do that. I think they should adopt whatever will best present their position.

Let me check just a moment, please.

DR. HALL: You might need a petition for an oral hearing. We don't know. Rule 2.730, Subsection F, permits an announcement on the record during a hearing of the ruling without securing a separate order. We feel that this is adequate to fully refer that to the Commission.

At this time, let us recess, to reconvene in this room at 3:45.

(Recess.)

UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

IN THE MATTER OF VERMONT YANKEE NUCLEAR POWER CORPORATION (VERMONT YANKEE NUCLEAR POWER STATION)	DOCKET No. 50-271

ORDER OF REFERRAL OF RULINGS

The Atomic Safety and Licensing Board, in accordance with Section 2.730(f) of the Commission's Rules of Practice, refers to the Atomic Safety and Licensing Appeal Board for further consideration and determination the rulings made by the Licensing Board, as reflected at pages 2187-8 of the transcript, respecting the processing and subsequent transportation and storage of high level wastes from and after the operation of a nuclear fuel waste processing plant. The rulings of the Board sustained objections to interrogation that sought to render relevant in this operating license proceeding the inquiries concerning levels of radioactivity and protections therefrom in operations of some other company's processing plant and the transportation therefrom of high level wastes to some undefined storage area. The rulings are referred for determination in view of the scope of Appendix D to 10 Code of Federal Regulations, published on September 9, 1971, which provided for considerations of effects of construction or operation of any proposed licensed activity which would have a significant impact on the environment.

The Atomic Safety and Licensing Board also refers to the Atomic Safety and Licensing Appeal Board the Motion

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of Intervenor Natural Resources Defense Council, Inc. (NRDC) requesting, in accordance with Section 2.730(g) of the Commission's Rules of Practice, certification of the above identified referral to the Atomic Energy Commission upon the ground that a broad policy question is involved which, it is asserted, should receive the Commission's determination.

Copies of all of the attached papers have been served by the movant upon all parties, and that service need not be duplicated. Copies of this Order of Referral have been served by the Board upon all parties.

ATOMIC SAFETY AND
LICENSING BOARD

By Samuel W. Jensch, *Chairman*

Attachments:
12/51/71 Ltr NRDC to Chairman Schlesinger
12/20/71 Motion Requesting Referral to AEC
12/20/71 Referral Brief of NRDC
w/Exhibits A through E

Issued:
December 29, 1971
Germantown, Maryland

[EXCERPTS FROM FINAL ENVIRONMENTAL STATEMENT FOR VERMONT YANKEE NUCLEAR POWER CORPORATION, USAEC DIRECTORATE OF LICENSING (July 7, 1972)]

Section III D.2

2. *Radioactive Waste*

In the operation of nuclear power reactors, radioactive material is produced by fission and by neutron activation reactions of metals and material in the reactor system. Small amounts of gaseous and liquid radioactive wastes enter the effluent streams, which are monitored and processed within the Station to minimize the radioactive nuclides that will ultimately be released to the atmosphere and into the Connecticut River at low concentrations under controlled conditions. The radioactivity that may be released during operation of the Station at full power will be in accordance with the Commission's regulations, as set forth in 10 CFR 20 and 10 CFR 50. In addition, modifications will be made to the Station's radwaste system to reduce these levels to the lowest level practicable, and the applicant has stated that he intends to use the present waste treatment system to its full capability.

The waste treatment systems described in the following paragraphs are designed to collect and process the gaseous, liquid and solid waste which might contain radioactive materials.

The waste handling and treatment systems currently installed at the Station are discussed in detail in the Final Safety Analysis Report and in the applicant's Environmental Report, Vermont Yankee Nuclear Power Station, and Supplement to the Environmental Report dated December 21, 1971.

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a. *Liquid Radioactive Waste*

In a boiling water reactor, the circulating primary coolant water receives radioactive isotopes from two sources: (1) fission products escape into this water through defects in the cladding of the fuel rods as the water passes through the reactor core, and (2) corrosion products and erosion products from the reactor coolant circulation system are carried along in this water and made radioactive by neutron (and proton) bombardment in the reactor. To keep the activity level of the reactor primary coolant water low, a fraction of the circulating stream is continually withdrawn, passed through a filter-demineralizer system (the "reactor water cleanup system") to remove suspended and dissolved radioactive (and nonradioactive) materials, and returned to the primary coolant stream. The radioactivities of many of the radionuclides present in the primary coolant were calculated for the condition when equilibrium has been reached between escape of these nuclides from failed fuel elements and their removal by decay, purification of the coolant, and leakage. These activities were calculated with the assumption that 0.25% of the total thermal power is produced in leaking fuel elements and that the reactor water cleanup system had a removal efficiency of 90% for all fission products except molybdenum and yttrium.

Molybdenum and yttrium are not generally removed by demineralizers. However, if no removal is assumed, the calculated activity in the reactor coolant is significantly greater than activity measured in operating boiling water reactors. By ratioing the total activities of the coolants, on the basis of such measurements, the activity level of tellurium is also overpredicted by the calculations. Empirical removal efficiencies were, therefore, used for these isotopes to obtain the primary coolant activities considered in the effluent calculations.

The origins and processing of liquid radioactive wastes in the Vermont Yankee Nuclear Station are shown in Fig. III-15. These wastes will be segregated for treatment into two main streams — the equipment drains stream and the floor drains stream. The equipment drains stream will consist of about 15,000 gpd of "high purity" water which is low in dissolved and suspended solids content. The floor drains stream will consist of about 8,000 gpd of "low purity" effluent which is somewhat lower in radioactivity but higher in dissolved and suspended solids. The processing systems will be operated batchwise with wastes accumulated in tanks and processed as necessary.

The equipment drain stream will be purified by filtration and demineralization, and then returned to the reactor makeup water. The origins of the waste streams entering the system are leakage from the pumps and valves involved in circulating condensate, feedwater, and waste liquids and from the control rod, scram, shutdown, and recirculation systems; drainage and overflows from the above systems; heat exchangers; steam lines; fuel pool system; and reactor water cleanup system.

When enough effluent has collected in the waste collector tank the effluent is passed through a precoat filter and a mixed bed demineralizer. The filter removes sludge and suspended corrosion products. The efficiency of the demineralizer in absorbing metallic and nonmetallic ions from the solution depends on a number of factors, such as the identity of the ion, the acidity of the solution, and the amount of material already absorbed in the resin.

After passage through the filter-demineralizer system, the effluent is pumped to the waste sample tanks, where its radioactivity is measured. If the radioactivity level is low

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enough (e.g., $< 3 \times 10^{-3}$ μCi/cm^3), the effluent is pumped to the 500,000-gal condensate storage tank to be used as makeup primary coolant water. However, if the activity of the effluent is too high for use as makeup water, the effluent is not sent to the condensate storage tank but is returned to the waste collector tank.

The daily volume of wastes entering these streams (15,000 gal) is made up of 6,000 gal from the drywell equipment drain sump (at the activity of the primary coolant); 2000 gal from the reactor equipment drain sump, 1000 gal from the radioactive building equipment drain sump, 3000 gal from the turbine building drain sump, and 3000 gal of miscellaneous drains (all at an activity of 1% of that of the primary coolant, representing small leakages that are diluted with other process liquids). An overall decontamination factor of about 100 must be realized in the filter-demineralizer to reduce the activity below the required 3×10^{-3} μCi/cm^3. The anticipated releases shown in Table III-1 are based on achieving this decontamination factor and on recycling 90% of the influent to the condensate storage tank. Operating experience at other similar reactor stations has shown that this is attainable.

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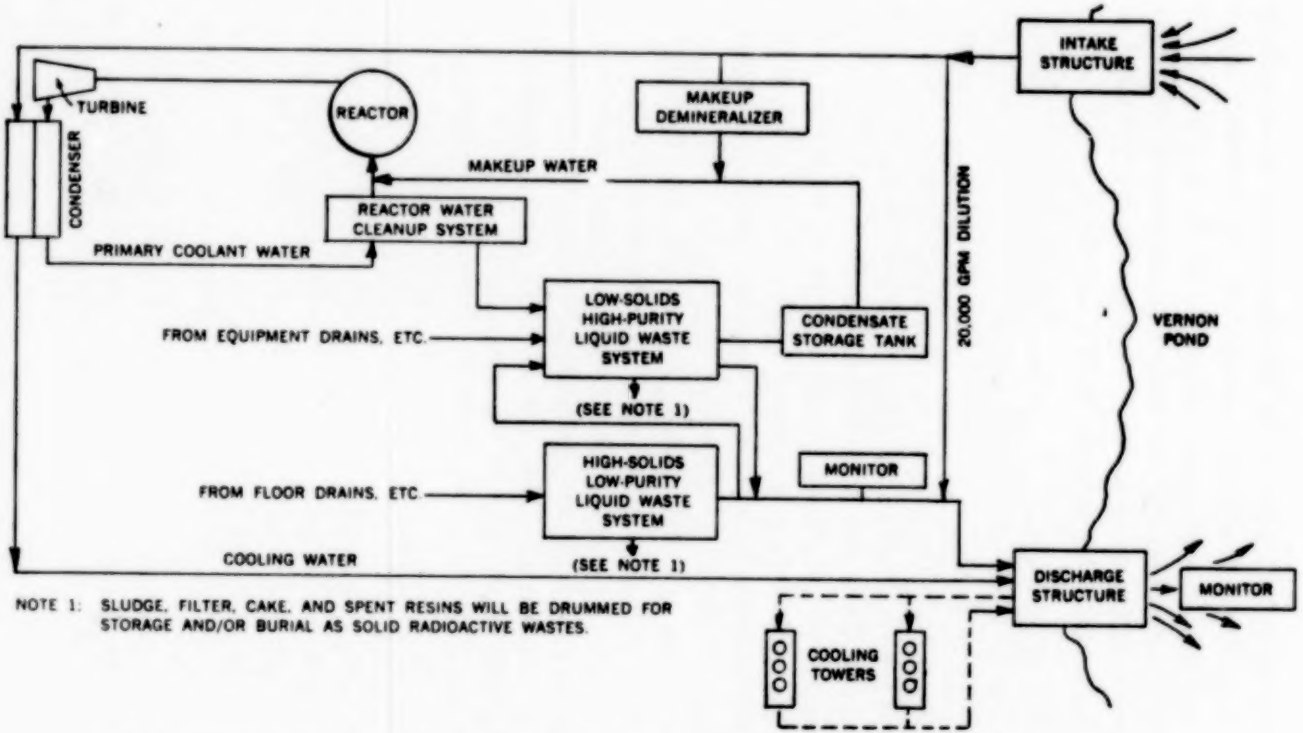

Fig. III-15. Schematic of Vermont Yankee Nuclear Power Station Liquid Radioactive Waste System.

The floor drain system collects liquid wastes from floor drain sumps which are estimated to be 2000 gpd from the reactor building floor drain sump, 1000 gpd from the radioactive waste building floor drain sump, 2000 gpd from the turbine building floor drain sump (all at a radioactivity of 1% of the primary coolant), and 3000 gpd from the drywell floor drain sump (at the activity of the primary coolant). These liquids are processed through a filter to the floor drain sample tank, sampled, and released if the activity is low in comparison to applicable regulations. If the radioactivity content of the sample tank is such that a discharge limit would be approached, the waste can be held in the tank for a period of time to allow radioactivity reduction through decay. If this delayed release is not practical because of the volumes of waste being generated, or because the radionuclides are long lived, then the liquid in the sample tank will be pumped through the equipment drain system filter and demineralizer to the waste sample tank for analysis. This waste may not be of sufficient chemical purity to allow reuse within the reactor system. In this case, the waste sample tank contents would be diluted and discharged. The anticipated releases shown in Table III-1 are based on processing all liquid wastes from the floor drains through the equipment drain system (with a decontamination factor of 100) and releasing them.

Chemical wastes collect in the chemical waste tank. Subsequent treatment is dependent upon the results of analysis to determine chemical purity of the liquid. When this shows that the waste can be chemically neutralized sufficiently to allow treatment as a low purity waste, the contents of the chemical waste tank will be directed, after neutralization, to the floor drain collector tank for treatment as low purity wastes as described above. If the chemical nature or radioactivity content precludes treatment as low purity

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waste, this liquid may be pumped into drums, mixed with water-adsorbent material to remove free water and handled as a solid waste. Detergent wastes are collected in the decontamination solution tank where they are sampled for radioactivity content. These wastes will then be filtered, diluted, and discharged. Table III-1 includes the calculated releases from these sources.

b. *Gaseous Wastes*

During power operation of the Station, radioactive materials released to the atmosphere in gaseous effluents include fission product noble gases (krypton and xenon); activated argon and nitrogen; halogens (mostly iodines); tritium contained in water vapor; and particulate material including both fission products and activated corrosion products. Fission products will be released to the coolant and carried to the turbine by the steam if defects occur in the fuel clad or if uranium is present as an impurity in, or on, the clad itself.

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TABLE III-1

Annual Release of Radioactive Material in Liquid Effluent from Vermont Yankee Nuclear Power Station (100% Power)

Nuclide	Ci/year	Nuclide	Ci/year
^{89}Sr	0.45	^{132}I	0.042
^{90}Sr	0.029	^{133}I	0.14
^{91}Sr	0.00044	^{135}I	0.00013
^{90}Y	0.10	^{134}Cs	0.25
^{91m}Y	0.028	^{136}Cs	0.073
^{91}Y	0.22	^{137}Cs	0.19
^{93}Y	0.0044	^{137m}Ba	0.036
^{95}Zr	0.0047	^{140}Ba	0.65
^{97}Zr	0.000079	^{140}La	0.5
^{95}Nb	0.0048	^{141}Ce	0.0050
^{97m}Nb	0.000076	^{143}Ce	0.00055
^{97}Nb	0.0000079	^{144}Ce	0.0032
^{99}Mo	0.095	^{143}Pr	0.0040
^{99m}Tc	0.091	^{144}Pr	0.0032
^{103}Ru	0.0034	^{147}Nd	0.0016
^{106}Ru	0.0011	^{51}Cr	0.040
^{103m}Rh	0.0034	^{54}Mn	0.0035
^{105}Rh	0.00033	^{55}Fe	0.18
^{106}Rh	0.0011	^{59}Fe	0.0066
^{127m}Te	0.00097	^{58}Co	0.42
^{127}Te	0.0010	^{60}Co	0.044
^{129m}Te	0.0091	^{65}Zn	0.000088
^{129}Te	0.0058	^{69m}Zn	0.000021
^{131m}Te	0.0010	^{187}W	0.016
^{131}Te	0.00019	^{24}Na	0.0021
^{132}Te	0.040	^{32}P	0.0015
^{130}I	0.000096	Total	~ 5
^{131}I	1.2	^{3}H	~ 20

The major source of gaseous waste activity during normal Station operation will be the off-gas from the steam condenser air ejectors. Other sources include primary containment purge, the gland seal off-gas system and the reactor building, raidoactive waste building, and the turbine building exhaust systems. Figure III-16 is a schematic of these systems.

Prior to release, the off-gases from the main condenser air ejectors will be delayed for a minimum of 30 min in a holdup pipe (to allow decay of activity of short-lived radioactive noble gases) and filtered through high efficiency particulate filters and charcoal adsorbers. Release will be through the main station 318-ft-high stack.

The reactor building exhaust system removes air from the reactor building ventilation system and from the drywell and torus purge exhaust system. This air, which normally contains low concentrations of activity, is discharged to the main station stack. The system is so arranged that the exhaust air can be directed to the standby gas treatment system (high efficiency particulate filters and charcoal adsorbers in series) for release through the main station stack if the activity level is high. The primary containment (drywell) is normally a sealed volume. However, during periods of refueling, maintenance, or whenever primary containment access is required, the potential exists for the release of airborne radioactivity to the environment. In such cases, air is removed through the drywell and torus purge system (prefilters and high efficiency particulate filters) and discharged to the reactor building vent stack.

The turbine building exhaust system which is expected to contain low concentrations of activity, primarily from steam system leakage, draws air from the turbine building and is discharged to the atmosphere through the main station stack which is continuously monitored.

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The steam/air exhaust from the turbine sealing system passes through a gland seal condenser where the steam is condensed and the non-condensables are exhausted to the gland seal holdup line. The small quantity of radioactive gases released by way of the gland seal off-gas system is delayed for about 2 min to allow decay of the major activation gases (^{16}N and ^{19}O) prior to release through the main station stack. All sources of gaseous wastes are continuously monitored to assure that effluent releases are within applicable standards.

On the basis of operating experience with reactors of similar design, it is expected that the off-gas system described above will keep releases of gaseous radioactive wastes well within the limit specified in 10 CFR 20. In order to reduce these levels to the lowest level practicable during extended power operation, the applicant plans to install additional gaseous holdup equipment. A modification to the present system will provide recombination of the hydrogen and oxygen formed in the reactor coolant, a condenser to remove much of the water vapor, and a charcoal delay system to provide additional retention time for krypton and xenon and to provide additional adsorption of iodines and particulates. The modified system is expected to be operational by the time of the first refueling. The staff anticipates that the proposed modification will result in a reduction of off-gas activity (curies of noble gases) released by a factor of at least 20 relative to a 30-min holdup system and that ^{131}I from all gaseous sources will be reduced to less than 0.6 Ci/year.

On the basis of experience at other operating plants, gaseous activity releases for Vermont Yankee are estimated at 3,000,000 Ci/year, prior to the installation of the modified treatment system. However, based on commitments made in the Technical Specifications to the operating license, the

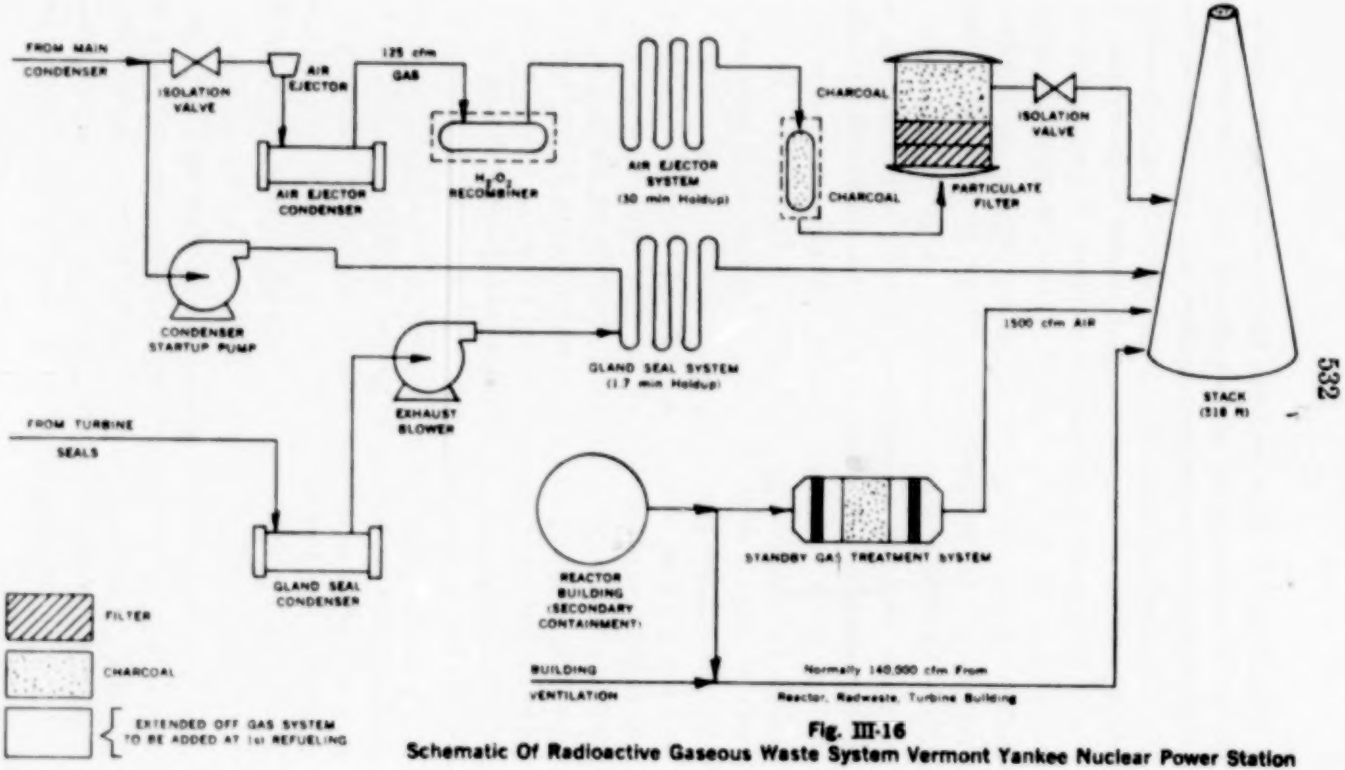

Fig. III-16
Schematic Of Radioactive Gaseous Waste System Vermont Yankee Nuclear Power Station

532

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actual effluents will be administratively controlled to an annual average rate of 22,000 μCi/sec or about 700,000 Ci/yr. The expected distribution is shown in Table III-2.

c. *Solid Radwaste*

Since both the condensate and reactor water cleanup systems use pre-coat Powdex type ion exchange resins, which are not regenerated, most of the radioactivity from corrosion and fission products is collected and retained on these resins. In addition, activity removed from the high purity wastes by the liquid radwaste system demineralizer is also retained. Therefore, the bulk of the solid radioactivity wastes consists of spent ion exchanger resins. The remaining solid wastes consist of filter sludges, air filters, and miscellaneous paper and rags.

Ion exchange resins are dewatered in phase separators and placed in shielded casks. Dry wastes are compacted in drums. No solid wastes will be stored permanently at the Station. All solid radioactive wastes will be packaged and shipped offsite for disposal at an AEC licensed disposal site in accordance with AEC and Department of Transportation (DOT) regulations.

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SECTION III.E

TRANSPORTATION OF NUCLEAR FUEL AND SOLID RADIOACTIVE WASTES

The nuclear fuel for the Vermont Yankee reactor is slightly enriched uranium in the form of sintered uranium oxide pellets encapsulated in zircaloy fuel rods. Each fuel element is made up of 49 fuel rods, is about 14-½ ft long, and weighs about 680 lb. In each year of normal operation, about 88 fuel elements will be replaced.

The applicant has indicated that unirradiated fuel for the reactor will be transported by truck from Wilmington, North Carolina, to the plant site, a shipping distance of about 700 miles. The applicant has not stated where the irradiated fuel or solid wastes will be shipped, but he did indicate irradiated fuel will be transported by truck or rail and solid wastes by truck. Distances of 900 miles for shipping the irradiated fuel and of 500 miles for shipping the solid radioactive wastes have been assumed.

1. *Unirradiated Fuel*

The applicant has indicated that unirradiated (cold) fuel will be shipped in AEC-DOT approved containers which hold two fuel elements per container. About three truckloads of 16 containers each will be required each year.

2. *Irradiated Fuel*

Fuel elements removed from the reactor will be unchanged in appearance and will contain some of the original ^{235}U (which is recoverable). As a result of the irradiation and fissioning of the uranium, the fuel element will contain large amounts of fission products and some plutonium. As the radioactivity decays, it produces radiation and "decay

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heat." The amount of radioactivity remaining in the fuel varies according to the length of time after discharge from the reactor. The fuel elements are placed under water in a storage pool for cooling and radioactive decay prior to being loaded into a cask for transport.

Although the specific cask design has not been identified, the applicant states that the irradiated fuel elements will be shipped after a minimum 90-day cooling period in approved casks designed for transport by either truck or rail. The cask will weigh perhaps 30 tons for truck or 100 tons for rail. Transport of the irradiated fuel will require an estimated 15 truckload shipments per year with six fuel elements per cask and one cask per truckload or five rail carload shipments per year with 20 fuel elements per cask and one cask per carload. An equal number of shipments will be required to return the empty casks.

3. *Solid Radioactive Wastes*

The applicant estimates that the solid radioactive wastes generated by the reactor will amount to from 1500 to 1800 ft^3/year of resins, 65 ft^3 of which may contain up to 15 curies per cubic foot (Ci/ft^3) and the rest, approximately 0.3 Ci/ft^3. In addition, about fifty 55-gal drums of miscellaneous wastes will be generated each year. The resins will be shipped in shielded casks weighing up to 45,000 lb when loaded. The applicant estimates that 8 to 12 truckloads of casks and drums of wastes each year will be shipped for disposal — probably to West Valley, New York — a shipping distance of about 500 miles.

. . . .

SECTION IX

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The construction and future operation of the Vermont Yankee Nuclear Power Station will use a certain amount of air, water, and land. The plant site and the nature and use of Vernon Pond will be affected. It is likely that the plant site will be used for power production for a long period. The staff believes that industry and population will increase in the region, which will lead to increased commitments of resources and perhaps irreversible changes in natural areas around Vernon.

Long-lived radioactive materials will be produced by fission of nuclear fuel in the core of the reactor and neutron activation of reactor parts near the core. The eventual disposal and storage of radioactive materials will require a certain amount of space, probably in an area remote from this plant, for a very long period of time, and could for all practical purposes be considered as an irreversible commitment of resources.

Other possible irreversible changes include the long-range effects on fish population, discussed in Sect. V.C.4, and transmission line requirements, in Sect. III.B.

Some of the ^{235}U, ^{238}U, and ^{239}Pu in the core of the reactor will be consumed and must be considered an irretrievable use of resources. Additional chemicals and fuels will be consumed for operation of associated plant equipment, such as emergency diesel generators and cooling towers. These commitments are small compared with the need for production of essential electrical energy for this area.

Of the ~ 60 acres of land used for plant buildings, it would appear that only a small portion of this land (less

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than 5 acres) beneath the reactor, control room, radwaste and the turbine-generator buildings and the cooling tower structures, would be irreversibly committed. Also, some components of the facility such as large underground concrete foundations and certain equipment are, in essence, irretrievable due to practical aspects of reclamation and/or radioactive decontamination. The degree of dismantlement of the plant, as previously noted, will be determined by the intended future use of the site, which will involve a balance of health and safety considerations, salvage values, and environmental effects.

ENVIRONMENTAL SURVEY OF

THE NUCLEAR FUEL CYCLE

PREPARED BY

U. S. ATOMIC ENERGY COMMISSION

DIRECTORATE OF LICENSING, FUELS AND MATERIALS

November , 1972

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SUMMARY

1. *Background and Purpose*

As part of the Federal licensing actions for individual nuclear power plants, detailed environmental statements are issued as public documents in conformance with the National Environmental Policy Act (NEPA) of 1969. These statements assess in detail the environmental impact associated with the construction and operation of the specific nuclear power plant, as well as the transportation of radioactive materials to and from the plant. This document is an environmental survey of the nuclear fuel cycle which supports the individual nuclear power plants.

Detailed environmental reviews are carried out in the separate licensing actions for each individual fuel cycle facility involved in the handling of source material, or special nuclear material, and for production facilities. Most of the facilities discussed in this environmental survey were constructed and licensed by the AEC prior to the enactment of NEPA. Accordingly detailed assessments of environmental impact have not been carried out on facilities that predated the NEPA act. It is expected, however, that detailed environmental reviews on the fuel cycle facilities processing the bulk of the nation's fuel material will be accomplished within the next few years as a result of planned modifications and expansions of existing plants, and construction of new ones. This environmental survey is not intended in any way to replace or preclude these thorough and meticulous analyses of individual plants.

2. *Scope*

This survey assesses the environmental considerations related to the currently predominant nuclear fuel cycle for uranium dioxide (UO_2) fueled, light-water moderated and

cooled nuclear power plants (LWR). In the United States, about 99% of the electric power generated from nuclear fuel incorporates this fuel cycle and a large percentage of the plants that are under consideration for construction permits or operating licenses will utilize this fuel cycle. In addition, estimates of the nuclear generation of electric power indicate that this predominance of LWR use will prevail through most of the present decade. Alternative nuclear fuel cycles involving plutonium recycle in the present generation of LWR power reactors and the fuel cycles for gas-cooled and fast breeder reactors will be considered in future documents.

The specific components comprising the LWR supporting fuel cycle are shown in Figure S-1 and include the following:

(a) Mining uranium ore.

(b) Milling and refining ore to produce uranium concentrates (U_3O_8).

(c) Production of uranium hexafluoride (UF_6) from uranium concentrates to provide feed for isotopic enrichment.

(d) Isotopic enrichment of uranium hexafluoride to attain reactor enrichment requirements using the gaseous diffusion process.

(e) Fabrication of nuclear reactor fuel including: converting UF_6 to uranium dioxide (UO_2), pelletizing, encapsulating in rods and assembling fuel elements.

(f) Reprocessing irradiated fuel and converting uranium to UF_6 for recycle through the gaseous diffusion plant for re-enrichment.

(g) Radioactive waste management of high level and other than high level waste, including long-term storage of wastes.

(h) Transportation activities associated with moving materials to and from each of the above operations.

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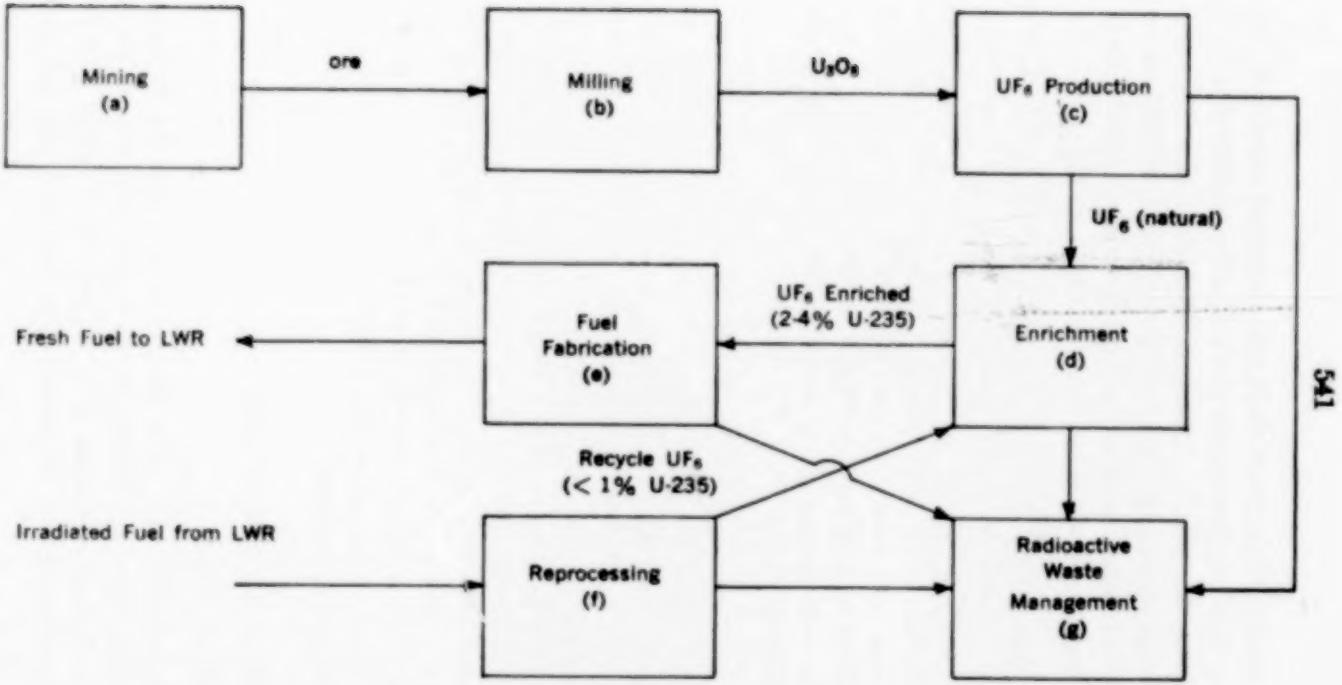

FIGURE S-1

Nuclear Fuel Cycle — Light Water Reactors **Uranium Dioxide Fueled — No Plutonium Recycle**

As discussed earlier, the environmental considerations relating to the construction and operation of the individual nuclear power plants, including transportation of radioactive materials to and from the power plant, are considered in detailed environmental statements in the separate licensing actions for each individual facility.

The supporting manufacturing operations to the nuclear fuel cycle have been reviewed and those that have been judged to be relatively remote, indirect, and less signficant contributors to the environmental impact of the nuclear fuel cycle have not been included in this statement. Typical operations in this category include production of commercial reagents such as sulfuric acid, hydrogen fluoride, ammonia, nitric acid, etc.

In many instances improvements in technology are available and plans are underway for incorporating these advances into production facilities. However, the primary basis of the present survey is today's industry with only minimal allowances for advances that may be accomplished in the future. In line with Commission practice, standards and criteria relating to fuel cycle facilities are continually evaluated and modified as appropriate to reflect experience, changing technology, and expansion of the industry. Thus, future environmental evaluations should also reflect continuing changes and advances as they affect the current mode and level of operations.

3. *Nuclear Industry Models*

(a) Model LWR

A "model LWR" was developed to relate the environmental considerations of the supporting fuel cycle to the annual operation of a nuclear power plant. In the development of this model, the requirements for each

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step of the fuel cycle have been reviewed for the current generation of 1000 MWe boiling water reactors (BWR) and pressurized water reactors (PWR). Both of these classes of LWR's utilize fuel in the form of sintered uranium dioxide pellets encapsulated in either stainless steel or zircaloy tubing. The maximum requirements in each step of the fuel cycle used to define the model LWR are listed in the first two columns of Table S-1 for both an initial core loading and an annual fuel reload along with fuel performance parameters used to define fuel requirements.

The useful life of LWR's has been estimated at between 30-40 years. For purposes of this analysis, a 30-year life has been conservatively assumed in defining the "annual fuel requirement" for the model LWR. The model LWR annual fuel requirement is defined as the sum of one initial core loading plus 29 annual reloads, averaged over the 30-year life of the plant, and is listed for each step of the fuel cycle in the third column of Table S-1. In discussing the environmental considerations of the nuclear fuel cycle steps in subsequent sections, resource use and effluent quantities have been related to this annual fuel requirement.

TABLE S-1

CHARACTERISTICS OF MODEL LWR (1000 MWe) MAXIMUM FUEL CYCLE REQUIREMENTS

	Initial Core	Annual Reload	Lifetime Average Annual Fuel Requirement
Irradiation level (MWD_t /MTU) x 10^{-3}	24	33	33
Fresh fuel assay (wt% U-235)	2.6	3.2	3.2
Spent fuel assay (wt% U-235)	0.76	0.84	0.84
Ore supply (MT) x 10^{-3}	332	82.5	91
Yellowcake U_3O_8 supply (MT)	665	165	182
Natural UF_6 (MT)	840	250	270
Separative work (MT SWU)	304	110	116
Enriched UF_6 (MT)	200	47	52
Enriched UO_2 (MT)	152	36	40
Fuel loading (MTU)	134	32	35

Bases

Reactor plant load factor — 80%

Enrichment tails assay — 0.25%

No plutonium recycle

Reloads include recovered uranium

Losses of 1% each in fuel fabrication and reprocessing

MT = metric ton = 2205 lbs.

MTU = metric ton uranium

MT SWU = separative work units in metric tons

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(b) Model Fuel Cycle Facilities

In some steps of the fuel cycle, numerous plants utilizing a wide variety of alternative processes and operations are involved. To evaluate environmental effects on a generic basis, a model fuel cycle facility for each component of the fuel cycle was defined.

Where industry has used one predominant method or one type of facility, that method or facility has been defined as the model facility. Where a single predominant operation has not been used, the mode of operation that imposes the most significant impact on the environment has been selected as the model. In some cases, where the nature of the impact from two or more modes of operation differs significantly, the aggregate operation of all plants, normalized to an appropriate annual capacity, has been selected as the model fuel cycle facility. The model fuel cycle facilities are not intended to represent particular plants. However, the models were selected to be representative of the industry and to lead to conservative or pessimistic assessments of the environmental considerations.

In the case of mining, milling, fuel fabrication, and radioactive waste management, the above approach resulted in the adoption of representative individual facilities as the model facilities. The UF_6 production model is a composite of the total industry complex of two plants that are presently in operation. The isotopic enrichment model is the total government-owned, contractor-operated complex of three plants as it essentially exists today. The reprocessing model is a composite of the total industry complex of three plants as they are planned for operation in the middle of this decade. Table S-2 gives the annual capacity of each

model fuel cycle facility and relates this capacity to the annual fuel requirement of the model LWR.

TABLE S-2

NUCLEAR FUEL CYCLE CAPACITIES RELATIVE TO THE ANNUAL FUEL REQUIREMENTS OF A MODEL LWR

	Fuel Cycle Plant Annual Capacity		Equivalent Number of Model LWR Annual Fuel Requirements
	Range	Model	
Uranium Mine (MT ore) x 10^{-3}	250-750	480	5.3
Uranium Mill (MT U_3O_8)	500-1100**	960	5.3
UF_6 Production (MTU)	5000-10,000	5000	27.5
Isotopic Enrichment (MT SWU)	6000-17,000	10,500*	90
UO_2 Fuel Fabrication (MTU)	300-1000	900	26
Spent Fuel Reprocessing (MTU)	300-1500	900	26

* Current operating level of industry and assumed model plant capacity.

** Characteristic of about 70% of current facilities.

The lifetime of each model fuel cycle facility was estimated to relate the land use to the model LWR annual fuel requirement. These estimates are generally 20 years which are on the low side of the expected lifetimes, so that the resulting land use numbers are conservative.

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4. *Approach to the Assessment of Environmental Considerations*

A detailed environmental review of an industrial process effluents involves the consideration of three components. These are (1) a source term or rate of effluent release, (2) a dilution term, or dispersion of the effluent throughout the medium under consideration, and (3) a population term, giving the distribution of human beings or biota affected by the effluent. To evaluate environmental impact, these factors must be combined.

In this broad survey of environmental considerations, the nuclear fuel cycle is treated on a generic basis. This approach permits an overview of the entire industry without keying the study to particular plants and manufacturers. In order to compensate for the lack of specific detail, effluent concentrations, radiation dose rates, and human population densities appropriate to the model fuel cycle facilities are estimated in each section.

Whenever possible, the environmental considerations have been related to the annual operation of a model LWR. This has been accomplished by normalizing the land use, water use, fossil fuel use, and effluent releases (including chemical, radiological, and thermal) to the model LWR annual fuel requirement, defined above in part 3.a of this section. The summary tables in each section, and the main summary table in this section, present the environmental considerations on this normalized basis.

It is recognized that the considerations presented in the summary tables may not adequately express the actual environmental impact of the fuel cycle. Accordingly, this information has been supplemented with concentrations and dose rates and compared with applicable and available

standards.[1] These additional considerations are presented in the summary text in each section, as well as in the summary text in part 5 of this Section. Whereas the information presented in the summary table is normalized to the annual operation of a model LWR, it is unrealistic to express concentrations, dose rates, and postulated accident effects on this basis. Accordingly, these considerations are based upon the nominal operation of the model fuel cycle facilities.

Estimates of effluent concentrations and radiation doses at the site boundaries of the model fuel cycle facilities are based upon experimental data or calculated values. Where measurements are available these data have been used. In most cases, however, it has been necessary to calculate these quantities, based upon estimated release rates and a model for dispersion. For the fuel reprocessing step, detailed analyses have been made of atmospheric dispersion in conjunction with the NEPA review and the preparation of the detailed environmental statement for specific plants. Therefore for that step in the nuclear fuel cycle the discussion is based upon actual meteorological conditions at the specific sites. For other components of the fuel cycle, for which no such data were available, an atmospheric dispersion model suitable for reactor accident analyses has been employed. This model utilizes X/Q values which are 1/10 of those given in AEC Safety Guide No. 3,[2] as recommended for realistic environmental evaluation in proposed Annex to Appendix D of 10 CFR 50.[3]

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[1] Most commonly used Federal, State and international standards were utilized for both radiological and non-radiological effluents.

[2] 4-30 day release curves in Safety Guide 3, Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors, USAEC, 2 Nov. 1970.

[3] Consideration of accidents in Implementation of the National Environmental Policy Act of 1969; Proposed Annex to Appendix D, 10 CFR 50; 1 December 1971.

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Where measured or estimated concentrations of chemicals in surface waters were available, these concentrations have been compared with the recommended criteria contained in the Water Quality Criteria "Green Book."[4] This volume represents the most comprehensive document on water quality requirements, and is used as a basic reference by agencies engaged in water quality standards setting activities. The recommended criteria are for source water which is to be subjected to normal water supply treatment prior to consumption as drinking water.

Airborne effluent concentrations have been compared with current EPA National Secondary Ambient Air Quality Standards,[5] where these are available. Secondary standards are designed to protect the public welfare from any known or anticipated adverse effects associated with the presence of air pollutants in the ambient air. For sulfur oxides, the secondary standard is 0.02 ppm, annual arithmetic mean, and for nitrogen dioxide it is 0.05 ppm annual arithmetic mean.

It is important to note that the discussion of environmental considerations in this document is confined to off-site effects; occupational health and safety of on-site workers are given major consideration by the AEC in detailed safety licensing reviews for individual facilities.

5. *Summary of Environmental Considerations*

The principal environmental considerations for each component of the nuclear fuel cycle, and the aggregate con-

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[4] Water Quality Criteria; Report of the National Technical Advisory Committee to the Secretary of the Interior; U. S. Federal Water Pollution Control Administration; Washington, D. C., April 1, 1968.

[5] National Primary and Secondary Ambient Air Quality Standards, published by the Environmental Protection Agency, Federal Register, Volume 36, Number 84, April 30, 1971.

siderations, normalized to the annual fuel requirement of a 1000 MWe model LWR, are summarized for the nuclear fuel cycle in Table S-3. Table S-3A similarly summarizes the considerations for each step in the nuclear fud cycle.

(a) Use of Natural Resources

(1) Land

The temporary land commitment amounts to 63 acres per annual fuel requirement for the model LWR. More than 70% of this land is an undisturbed area or which maybe withdrawn by fencing from active use by human habitation. The fencing also restricts migration of large animals. Approximately 18 acres are transformed from their original state by the construction of facilities. Less than 5 acres of land are permanently committed to the production of the annual fuel requirement for a model LWR.

At any time, the total temporary land commitment required by the fuel cycle to support a 1000 MWe LWR is about 750 acres. The total permanent land commitment, assuming a 30-year reactor life is about 140 acres.

To cast the land requirements into further perspective, a coal-fired power plant of 1000 MWe capacity requires the disturbance of approximately 200 acres per year for strip mining alone. The disturbed area for the nuclear fuel cycle amounts to approximately 18 acres per annual fuel requirement of a model LWR, which is less than 10% of the equivalent annual coal mining land commitment or equivalent to a 90 MWe coal-fired powerplant fuel requirement.

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TABLE S-3

Summary of Environmental Considerations For Nuclear Fuel Cycle (Normalized to Model LWR Annual Fuel Requirement)

	Total	Maximum Effect per Annual Fuel Requirement of Model 1000 MWe LWR
NATURAL RESOURCE USE		
LAND (acres)		
Temporarily committed	63	
Undisturbed area	45	
Disturbed area	18	Equivalent to 90 MWe coal-fired power plant
Permanently committed	4.6	
Overburden moved (MT x 10^{-6})	2.7	Equivalent to 90 MWe coal-fired power plant
WATER (gallons x 10^{-6})		
Discharged to air	163	~2% of model 1,000 MWe LWR with cooling tower
Discharged to water bodies	11,052	
Discharged to ground	123	
Total	11,338	<4% of model 1,000 MWe LWR with once-through cooling
FOSSIL FUEL		
Electrical energy (MW-hr. x 10^{-3})	317	<5% of model 1,000 MWe LWR output
Equivalent coal (MT x 10^{-3})	116	Equivalent to the consumption of a 45 MWe coal-fired power plant
Natural gas (scf x 10^{-6})	103	<0.2% of model 1,000 MWe LWR energy output

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TABLE S-3 — (cont.)

Summary of Environmental Considerations For Nuclear Fuel Cycle
(Normalized to Model LWR Annual Fuel Requirement)

	Total	Maximum Effect per Annual Fuel Requirement of Model 1000 MWe LWR
EFFLUENTS — CHEMICAL (MT)		
[1] Gases (including entrainment)		
SO_x	4400	
[2] NO_x	1170	Equivalent to emissions from 45 MWe coal-fired plant for a year.
Hydrocarbons	11.3	
CO	28.7	
Particulates	1156	
Other Gases		
F^-	0.7	Principally from UF_6 production and enrichment— Conc. within range of state standards-below level that has effects on human health.
Liquids		From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are:
$SO_4^=$	5.8	
NO_3^-	26	
Fluoride	0.4	
Ca^+	5.4	
Cl^-	8.2	
Na^+	13.5	
NH_3	10	NH_3 — 600 cfs
Fe	0.4	NO_3 — 20 cfs
		F — 7 cfs

[1] Estimated effluents based upon combustion of equivalent coal for power generation.

[2] 1.2% from natural gas use and process.

TABLE S-3 — (cont.)

Summary of Environmental Considerations For Nuclear Fuel Cycle
(Normalized to Model LWR Annual Fuel Requirement)

	Total	Maximum Effect per Annual Fuel Requirement of Model 1000 MWe LWR
Tailings Solutions (x 10^{-3})	240	From mills only — no significant effluents to environment.
Solids	91,000	Principally from mills — no significant effluents to environment.
EFFLUENTS — RADIOLOGICAL (curies)		
Gases (including entrainment)		Principally from mills — Maximum annual dose rate <4% of average natural background within 5 miles of mill. Results in 0.06 man-rem per annual fuel requirement. Due to dilute concentration and short half-life of principal component, exposure beyond a 5-mile radius is miniscule relative to natural background.
Rn-222	83	
Ra-226	0.02	
Th-230	0.02	
Uranium	0.046	
Tritium (x 10^{-3})	15.7	Principally from fuel reprocessing plants — Whole body dose is 4.4 man-rem for population within 50-mile radius. This is <0.005% of average natural background dose to this population.
Kr-85 (x 10^{-3})	350	
I-129	0.002	
I-131	0.02	
Fission Products	1.0	
Transuranics	0.004	

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TABLE S-3 — (cont.)

Summary of Environmental Considerations For Nuclear Fuel Cycle

Normalized to Model LWR Annual Fuel Requirement

	Total	Maximum Effect per Annual Fuel Requirement of Model 1000 MWe LWR
Liquids		
Uranium & daughters	2.4	Principally from milling — included in tailings liquor and returned to ground — no effluents; therefore, no effect on environment.
Ra-226	0.027	From UF_6 production-concentration <5% of 10 CFR 20 for total processing of 27.5 model LWR annual fuel requirements.
Th-230	0.27	
Th-234	0.01	From fuel fabrication plants-concentration <10% of 10 CFR 20 for total processing 26 annual fuel requirements for model LWR.
Other uranium daughters	0.01	
Ru-106	4	From reprocessing plants-maximum concentration <4% of 10 CFR 20 for total reprocessing of 26 annual fuel requirements for model LWR.
Tritium ($\times 10^{-3}$)	2.5	
Solids (buried)		
Other than high level	1200	From mills-included in tailings returned to ground-no significant effluent to the environment.
THERMAL (BTU $\times 10^{-9}$)	3370	<7% of model 1,000 MWe LWR.

TABLE S-3A

Summary of Environmental Considerations For Nuclear Fuel Cycle
Normalized to Model LWR Annual Fuel Requirement

Natural Resource Use	A Mining	B Milling	C UF_6 Prod.	D Enrichment	E Fuel Fab.	F Reprocessing	G Waste Management	H Transportation	Total
Land (Acres)									
Temporarily Committed	55	0.5	2.5	0.8	0.2	3.9	—	—	63
Undisturbed Area	38	0.2	2.3	0.6	0.16	3.7	—	—	45
Disturbed Area	17	0.3	0.2	0.2	0.04	0.2	—	—	18
Permanently Committed	2	2.4	0.02	0	0	0.03	0.2	—	4.6
Overburden moved (MT x 10^{-6})	2.7	—	—	—	—	—	—	—	2.7
Water (gallons x 10^{-6})									
Discharged to air	—	65	3.7	90	—	4.0	—	—	163
Discharged to water bodies	—	—	41	11000	5.2	6.0	—	—	11052
Discharged to ground	123	—	—	—	—	—	—	—	123
Total Water	123	65	44.7	11090	5.2	10.0	—	—	11338
Fossil Fuel									
Electrical energy (MW-hr x 10^{-3})	0.25	2.7	2.1	310	1.7	0.45	—	—	317
Equivalent Coal (MT x 10^{-3})	0.09	0.97	0.76	113	0.62	0.16	—	—	116
Natural Gas (scf x 10^{-6})	—	68.5	31	—	3.6	—	—	—	103

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TABLE S-3A — (cont'd)

Summary of Environmental Considerations For Nuclear Fuel Cycle
Normalized to Model LWR Annual Fuel Requirement

Effluents	A Mining	B Milling	C UF_6 Prod.	D Enrichment	E Fuel Fab.	F Reprocessing	G Waste Management	H Transportation	Total
Chemical (MT)									
Gases(1)									
SO_x	3.5	37	29	4300	23	6.2	—	—	4400
NO_x	0.9	15.9(2)	10(3)	1130	6	7.1(4)	—	—	1170
Hydrocarbons	0.009	1.3(2)	0.6(2)	11	0.06	0.02	—	—	13.0
CO	0.02	0.3	0.2	28	0.15	0.04	—	—	28.7
Particulates	0.9	9.7	7.6	1130	6	1.6	—	—	1156
Other Gases									
F^-	—	—	0.11	0.5	0.005	0.05	—	—	0.7
Liquids									
$SO_4^=$	—	—	—	5.4	—	0.4	—	—	5.8
NO_3^-	—	—	—	2.7	23	0.2	—	—	26
Fluoride	—	—	—	—	0.4	—	—	—	0.4
Ca^+	—	—	—	5.4	—	—	—	—	5.4
Cl^-	—	—	—	8.2	—	0.02	—	—	8.2
Na^+	—	—	—	8.2	—	5.3	—	—	13.5
NH_3	—	—	—	—	10	—	—	—	10
Tailings Solutions (x 10^{-3})	—	240	—	—	—	—	—	—	240
Fe	—	—	—	0.4	—	—	—	—	0.4
Solids	—	91,000	40	0.2	26	—	—	—	91,000

(1) Estimated effluents based upon combustion of equivalent coal for power generation
(2) Combined effluents from combustion of coal and natural gas
(3) 25% from natural gas use
(4) 77% from process

TABLE S-3A — (cont'd)
Summary of Environmental Considerations For Nuclear Fuel Cycle
Normalized to Model LWR Annual Fuel Requirement

Effluents (cont'd)	A Mining	B Milling	C UF_6 Prod.	D Enrich-ment	E Fuel Fab.	F Repro-cessing	G Waste Manage-ment	H Transpor-tation	Total
Radiological (Curies)									
Gases (including entrainment)									
Rn-222	—	74.5	—	—	—	—	—	—	83
Ra-226	—	0.02	—	—	—	—	—	—	0.02
Th-230	—	0.02	—	—	—	—	—	—	0.02
Uranium	—	0.03	0.014	0.002	0.0002	—	—	—	0.046
Tritium (x 10^{-3})	—	—	—	—	—	15.7	—	—	15.7
Kr-85 (x 10^{-3})	—	—	—	—	—	350	—	—	350
I-129	—	—	—	—	—	0.002	—	—	0.002
I-131	—	—	—	—	—	0.02	—	—	0.02
Fission Products	—	—	—	—	—	1.0	—	—	1.0
Transuranics	—	—	—	—	—	0.004	—	—	0.004
Liquids									
Uranium & Daughters	—	2	0.33	0.02	0.02	—	—	—	2.4
Ra-226	—	—	0.027	—	—	—	—	—	0.027
Th-230	—	—	0.27	—	—	—	—	—	0.27
Th-234	—	—	—	—	0.01	—	—	—	0.01
Tritium (x 10^{-3})	—	—	—	—	—	2.5	—	—	2.5
Other Uranium daughters	—	—	—	—	0.01	—	—	—	0.01
Ru-106	—	—	—	—	—	4	—	—	4
Solids (buried)									
Other than high level	—	1200	0.3	—	0.06	—	—	—	1200
Therm[illegible] Btu x 10^{-9})	—	69	30	3200	9	61	—	0.03	3370

(2) Water

Water is used in the nuclear fuel cycle both as a coolant and for process requirements. Water uses have been grouped into three categories based upon the method of return of the water to the biosphere. Water is evaporated into the air, discharged into water bodies or is returned to the ground.

The largest quantity of water involved is the 11 billion gallons required to remove the waste heat from the power stations supplying electrical energy to the enrichment step of the nuclear fuel cycle in the production of an annual fuel requirement. Assuming once-through cooling at these power stations, all of this water is returned to surface water bodies. An additional 338 million gallons of water are directly involved at the fuel cycle plants for cooling, process, and dewatering requirements, totaling 11.3 billion gallons of water moved in producing the annual fuel requirement for the model LWR.

In order to remove the waste heat from a 1000 MWe nuclear power plant on a once-through basis, approximately 300-400 billion gallons of water are pumped annually. Thus, the total demand for water in the components of the nuclear fuel cycle constitutes less than 4% of the water requirement of a 1000 MWe LWR.

The largest single direct dissipation of water by evaporation in the nuclear fuel cycle is for process cooling in the enrichment step. The gaseous diffusion plants evaporate approximately 90 million gallons of water to the atmosphere per model

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LWR annual fuel requirement. This constitutes approximately 55% of the 163 million gallons of water discharged to the atmosphere in the nuclear fuel cycle. As a point of reference, a 1000 MWe LWR utilizing cooling towers would evaporate approximately 7 billion gallons of water per year to the atmosphere or more than 40 times the evaporative use of water by the nuclear fuel cycle to produce the fuel for a year's operation.

The requirement for uranium mine drainage moves over 120 million gallons of water per model LWR annual fuel requirement. However, minimum depletion is involved, since the water is pumped from the bottom of the mine pit to the ground surface for return to ground water at some other location with some being returned to the atmosphere by evaporation.

(3) Other

The uranium enrichment component of the nuclear fuel cycle requires over 98% of the electrical energy required by the fuel cycle. The total electrical requirements are 317 x 10^3 MW-hr for the annual fuel requirement of a model LWR. A 1000 MWe LWR would produce 7 million MW-hr in annual operation at a load factor of 80%. Thus the electrical requirements of the nuclear fuel cycle to produce fuel for this reactor are less than 5% of the energy produced by the reactor in a year's operation.

At present most of the electricity generated in the United States is produced in plants that burn fossil fuels. Assuming that coal comprises the bulk of fossil fuel utilization, the electrical energy require-

ments of the fuel cycle correspond to the consumption of 116 x 10^3 MT of coal. A 1000 MWe coal-fired station consumes approximately 2540 x 10^3 MT of coal annually. Thus, the nuclear fuel cycle for a model 1000 MWe LWR consumes about the quantity of coal required for a 45 MWe fossil-fueled plant.

Additionally, approximately 100 x 10^6 scf of natural gas are consumed for process heat, most of which is used in the milling operation. This quantity of natural gas could be used to generate roughly 10,000 MW-hr of electricity, which is less than 0.2% of annual output of the model LWR.

(b) Effluents

(1) Chemical

(i) Gaseous

At present, most of the power plants that supply electricity to the fuel cycle operations burn coal. Consequently, the combustion products of coal comprise nearly all of the airborne chemical effluents attributable to the fuel cycle and approximate the effects from the operation of a 45 MWe coal-fired power plant for a year. The main contributor to these gaseous effluents is the uranium enrichment step, which consumes over 98% of the electrical energy required by the fuel cycle. The existing plants draw power from the grids of large utilities; thus, no single power supply source can be identified with the gaseous effluents. To the extent that power is supplied by nuclear power plants, the total quantity of sul-

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fur dioxide, nitrogen oxides, hydrocarbons, carbon monoxide, and airborne particulates would be greatly reduced.

Fluorine is introduced into the fuel cycle during the UF_6 production step and is removed from the fuel material in the fuel fabrication step. As a result, fluorine becomes an airborne effluent from several steps of the nuclear fuel cycle. Although most of the fluorine gaseous wastes are effectively removed by scrubber treatment systems, approximately 0.7 MT per model LWR annual fuel requirement is released to the environment as an airborne contaminant. To put this quantity into perspective, the estimated fluoride emissions from four major industries are given in Table S-4.

TABLE S-4

ESTIMATED FLUORIDE EMISSIONS FROM MAJOR U. S. INDUSTRIES

Source	Emissions MT/yr.
Phosphate Industry (principally fertilizer manufacture)	17,000
Aluminum Manufacture	15,000
Steel Manufacture	39,000
Brick, tile, glass manufacture	19,000
TOTAL	90,000

Assuming a nuclear power generation industry of 140 model LWR's by 1980, approxi-

mately 100 MT of gaseous fluorides would be released annually by the entire nuclear industry at that time. This constitutes about 0.1% of the total annual quantity of fluoride emissions from the total of the industries noted in Table S-4.

Despite the trivial nature of this effluent in comparison with other major industries, the airborne fluoride release from the nuclear fuel cycle could constitute a potential for adverse environmental impact. Measurements or calculations of airborne fluoride concentrations at the site boundaries of specific plants fall within the range of 0.005-2.0 $\mu g/m^3$. For perspective, these concentrations are well below the level of observed adverse effects on human health, and they span the range of existing state standards.[6] State standards are used for comparison because there are no applicable Federal Standards.

At uranium mills and UF_6 production plant sites, the combustion of natural gas for process heat is a source of nitrogen oxide release to the environment. Dispersion calculations indicate that annual mean NO_x concentrations are within the EPA air quality standards of 100 $\mu g/m^3$. That standard, according to the Environmental Protection Agency, is adequate to protect the public welfare from any known or anticipated adverse effects associated with the presence of oxides of nitrogen in ambient air.

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[6] State of Washington: 0.5 $\mu g/m^3$
State of Pennsylvania: 5.0 $\mu g/m^3$

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(ii) Liquid

The largest quantity of liquid effluents, 240 x 10^3 MT of waste solutions per annual fuel requirement, contains sulfuric acid and other spent chemicals from the milling processes. This waste liquor, however, is discharged to the tailings pond, and since it does not normally contaminate unrestricted ground or surface bodies of water, it does not actually become an effluent stream.

Significant quantities of a number of chemicals are discharged in liquid effluents from the enrichment, fuel fabrication and reprocessing steps. The concentrations of fluorides, nitrates, and ammonia contained in the liquid waste streams from the model fuel fabrication plant are a possible source of adverse environmental effect. Dilution of these constituents by the receiving body of water by 1-3 orders of magnitude may be required to achieve drinking water source quality, depending upon the flow rate of the receiving body of water, its upstream quality and its downstream use. Efforts are in progress to minimize these releases from existing plants.

The liquid effluent quantities from enrichment appear large but generally are of chemicals that do not constitute a potential for adverse environmental effect and are at much lower concentrations. The enrichment step contributes the largest total quantity of liquid contaminants, but the concentrations of potential contaminants in the effluent streams are generally within the range of permissible stan-

dards.[7] Additional dilution by about 700 times by the receiving body of water decreases the concentrations well below acceptable levels. The release of hexavalent chromium, although small in quantity (<¼ MT/yr. from the model plant), is a potential concern and treatment facilities are being planned to reduce this effluent. Dilution of the iron concentration, a restrictive species, to approximately 0.003 ppm in the receiving bodies of water is two orders of magnitude below the recommended criteria.

In addition, small quantities of fluoride and nitrate wastes are contained in the liquid effluents from UF_6 production plants, while nitrates, sodium, chloride, and sulfates are the principal contaminants in liquid effluents from fuel reprocessing operations. In both cases, dilution in receiving rivers is adequate to reduce the incremental increase in concentration of these species to fractions of a ppm, and at least an order of magnitude beow Water Quality Criteria, U. S. Department of the Interior, April 1, 1968.

(iii) Solid

The greatest bulk of solid materias is generated in the open pit mining and miling operations. The barren rock and earth overburden produced by the mine temporarily constitute a waste material, but are essentialy returned to the barren mine as backfill and have not been considered as an effluent. The tailings from the mill are composed primarly of sand-

[7] Water Quality Criteria, U. S. Department of the Interior, April 1, 1968.

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stone and clays and constitute the major quantity (91,000 MT) of solid waste from the fuel cycle. They are pumped as a slurry to the tailings pond, where they are permanently stored as solids in a chemical form similar to their original condition, but containing slightly less radioactivity, since uranium has been removed.

The 50 tons of ash generated by the hydrofluor UF_6 production process consists of nonvolatile fluorides. Since the ash residue contains traces of radionuclides, it is packaged and shipped for burial at a licensed commercial disposal site and thus does not become an effluent to the environment.

Most of the fluorine added to the fuel cycle during the UF_6 production step is removed and precipitated as CaF_2 in the fuel fabrication step. The 26 MT of precipitated calcium fluoride per annual fuel requirement, occupying a volume of approximately 11 cubic yards, is buried in trenches on the site of the fuel fabrication plant and covered with backfill.

(2) Radiological

(i) Gaseous

The most significant gaseous radiological release from the fuel cycle derives from the fuel reprocessing step. Nearly all of the krypton-85, most of the tritium (in the model plant, 13% of the tritium is released to the watershed), minute quantities of radioiodine, other fission products, and transuranic particulates created

in the nuclear reactor fuel are released to the atmosphere from the reprocessing plant operations. However, the estimated annual radiation doses from the model plant to an individual at the site boundary are approximately 1.0 mrem to the whole body, 1.0 mrem to the bone, 15.5 mrem to the thyroid, and 14 mrem to the outer layer of skin. The thyroid dose is approximately 1% of the guideline limits recommended by the International Commission on Radiological Protection.

The long-term equilibrium buildup of Kr-85 in the atmosphere, due to one model 1000 MWe LWR, will eventually contribute approximately 80 man-rem annual whole body exposure to the entire population of the northern hemisphere (4 billion people). For comparison, the annual population dose to the same number of people from natural background radiation is approximately 500 million man-rem.

Small quantities of uranium and its daughters are released to the atmosphere in several steps of the fuel cycle. Data are unavailable for the total quantity of activity released from the mining operation, but attempts to measure radon concentrations in an open-pit mine revealed no significant alpha concentrations. Estimates of the site boundary concentration of thorium-230 from the model mill are approximately 15% of the 10 CFR 20 limit. In all other cases, the concentrations of uranium and its daughters are estimated to range from 1-4% of the 10 CFR 20 limits for unrestricted areas.

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(ii) Liquid

In the fuel reprocessing for a model LWR annual fuel requirement, approximately 2500 curies of tritium and 4 curies of ruthenium-106 are released in the liquid effluent from the model plant. Because of the effect of dilution of receiving streams, measurements in 1971 indicated that the maximum off-site concentrations of each species were less than 4% of the 10 CFR 20 limits.

Small quantities of uranium and its daughters are released in liquid effluents from each step of the fuel cycle. In the mining operation, several curies of activity are dissolved and suspended in the mine drainage water and returned to the ground. At the mill, approximately 2 curies of activity per annual fuel requirement are discharged in the tailings solution and thus are returned to their point of origin in the ground. In the remaining components of the fuel cycle, small quantities of radioactivity are released to receiving bodies of water. Off-site measurements in the vicinity of a UF_6 production plant indicate that annual mean radionuclide concentrations are maintained below 5% of the 10 CFR 20 limits. Estimates of the concentrations of radionuclides in effluent streams from enrichment and fuel fabrication plants indicate that concentrations are below 1% and 10% respectively of the 10 CFR 20 limits before dilution in receiving waters.

(iii) Solid

The most significant solid radiological waste consists of the fission products separated from the spent fuel of an annual fuel requirement in the reprocessing operation. These high level wastes will be stored on-site for a maximum of 10 yrs., and will ultimately be shipped, probably by rail, to a Federal storage facility. This Federal facility will be established to store and manage high level solid wastes under constant surveillance for up to 100 years, or until such time as a more permanent Federal repository can be established. The facility will be designed to prevent the release of any radioactive material to the environment under all credible environmental conditions and human actions. Therefore, such wastes will not be released as effluents to the environment.

The fuel element hulls and other fuel element parts contaminated with trace quantities of uranium, transuranics and fission products will be buried on-site at the reprocessing facility in a retrievable form and may be eventually shipped to a Federal storage facility. Other low specific activity material, such as laboratory wastes, may be buried on-site or at a commercial burial ground.

Other than high activity solid wastes from UF_6 production, fuel fabrication, and reprocessing facilities amounting to a few curies per annual fuel requirement are packaged and shipped by truck to a licensed commercial burial site. The geological and hydrological

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characteristics of these burial sites are such that little or no migration of radioactive material from the site is postulated. The burial sites are enclosed by fences and access is controlled.

The solid waste tailings from the milling operation, which contain most of the uranium daughter products originally in the ore (approximately 1200 curies per annual fuel requirement), are slurried in the waste milling solutions. The solutions are pumped to the tailings retention pond and consequently the activity is contained on-site.

The public is exposed to a small amount of direct radiation exposure during the normal shipment of solid wastes. Approximately 600,000 people along the route of travel will receive a population dose of roughly 0.036 man-rem during the rail shipment of high level solid wastes from the fuel reprocessing plant site to the Federal storage facility. The population dose to approximately 210,000 people from the truck shipments of low specific activity solid wastes to commercial burial sites consists of roughly 0.006 man-rem. These dosages constitute less than 0.0001% of the natural background radiation.

(3) Thermal

Approximately 3.4 x 10^{12} Btu of waste heat are discharged to the biosphere in the production of a model LWR annual fuel requirement. For purposes of comparison, the waste heat from the annual operation of a 1000 MWe model LWR is ap-

proximately 50 x 10^{12} Btu. Thus, the thermal effluents from the supporting fuel cycle constitute less than 7% of the thermal release from the model LWR.

About 95% of the waste heat from the supporting fuel cycle originates in the uranium enrichment step. In this step, 1.6 x 10^{12} Btu are discharged to water bodies at the supporting electric power stations (assuming that the power stations that supply electricity to the gaseous diffusion plants utilize once-through cooling), 0.5 x 10^{12} Btu are discharged to the atmosphere through the stack at the electric power stations, and 1.1 x 10^{12} Btu are discharged to the atmosphere at the gaseous diffusion plants from cooling towers.

The operation of cooling towers leads to local misting and fogging under certain meteorological conditions. At the gaseous diffusion plants, however, this effect does not extend beyond the site boundaries. The impact of the thermal discharge to water bodies is difficult to estimate, since the power is drawn from the grids of large utility complexes and the heat is dissipated to a number of receiving bodies of water.

(c) Accident Considerations

The history of the nuclear fuel cycle to date indicates that accidents in fuel cycle facilities which could result in significant effects on the off-site environment are highly improbable. This record of the commercial nuclear fuel cycle industry has been accomplished by the consideration of safety as a controlling factor in all its functions. Each applicant in his license application is required to analyze potential conditions that could result in the release of

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radioactivity beyond the plant confines and by proper design, construction and operation to minimize such releases. As a further assurance, the Regulatory Staff performs a detailed independent safety evaluation of each commercial fuel cycle facility which includes at least the following elements:

(1) *Site Analysis* — Site conditions such as geography, meterology, hydrology, and seismology are reviewed; in addition, maximum natural phenomena criteria are considered in the case of plutonium plants and reprocessing plants.

(2) *Process Evaluation* — The process flow sheet is reviewed in detail to identify potential effluents and safety problems during normal and abnormal operations.

(3) *Structures and Systems* — The building itself, including modules, layouts, etc., is reviewed for safety, emergency escape, limiting the spread of contamination and prevention and control of fires.

Systems — Ventilation, air cleaning, waste treatment, safety instrumentation and monitoring systems are analyzed for suitability under normal and abnormal conditions.

Equipment — The adequacy and reliability of the process and utility equipment are reviewed including the Quality Assurance (QA) on design, construction, installation, operation, and maintenance. For plutonium conversion and fabrication facilities and for reprocessing plants, Appendix B of 10 CFR 50 covering QA requirements is a requirement.

(4) *Radiation Safety and Nuclear Safety Programs* — The review includes contamination control consid-

erations, ventilation system performance, exposure assessment for workers and control of such exposure. Effluents and effluent treatment and montioring systems for both liquid and gaseous streams leaving the plant are evaluated. Accident analyses that include consideration of criticality, radiation safety, and nonradiation safety problems are performed. In the fuel cycle plants handling special nuclear material, both liquid and solid systems are evaluated for criticality safety.

(5) *Procedures* — The licensee is required to have detailed operating and maintenance procedures. The training and testing programs for operators are reviewed. Particular attention is given to fuel reprocessing plant operators who are tested and licensed by the AEC. The licensee must provide a corporate hazard committee or some similar organization that has responsibility for review of new processes and plant changes. Safety audits of operations are required to be made by the licensee who must report the results of these audits.

Emergency plans are submitted by the licensee and are reviewed for adequacy and detailed coverage. Emergency plans are required for all the special nuclear material plants and for fuel reprocessing plants in accordance with licensing conditions or Appendix E of 10 CFR 50.

(6) *Materials and Plant Protection Evaluation* —In addition to the licensing functions of health and safety evaluation is the safeguards program of the applicant for the control of special nuclear material and the means by which he intends to protect those materials against theft, diversion, or sabotage.

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In addition to requirements for care in design, construction, and operations of nuclear fuel cycle facilities, each licensee is required to report incidents to the cognizant AEC Regulatory Operations office which either have or threaten to cause any of the following types of events:

(i) Radiation exposure of individuals beyond stated limits.

(ii) Release of radioactive materials in daily averaged concentrations of more than 500 times limits specified in 10 CFR 20, Appendix B, Table II.

(iii) A loss of operations of any affected facility for a period of greater than one day.

(iv) Damage to property of over $1000.

The information in these reports is used as a basis for corrective action to prevent similar events from occurring in existing plants and is taken into account in the licensing actions on new or modified facilities of a similar nature. Such information is also evaluated to determine the need for new or modified standards and criteria.

The effectiveness of these measures to date is borne out by the fact that the incidents which have occurred in fuel cycle facilities in this country to date have neither resulted in significant injury nor endangered the health of any individual in the general public. Nevertheless, for each licensed operation of the fuel cycle, a series of potential accidents with environmental effects judged to range from trivial to serious have been postulated and evaluated in the safety analysis that is performed before the individual facility license is issued. Records to date indicate few if any of the routine type accidents involving special nuclear material have had any measurable effects on the environment. Thus, the review of accidents for this statement has

been concentrated upon the most serious accidents that either have occurred or realistically can be postulated. The estimated radiological environmental effects of the most significant of these accidents are summarized in Table S-5 which lists the resulting calculated radiation exposure in unrestricted areas.

TABLE S-5

SUMMARY OF OFF-SITE EXPOSURES FROM POSTULATED ACCIDENTS

Accident	Fuel Cycle Component	Calculated Off-Site Exposure (rem)	Principal Affected Organ
Criticality Incident[a]	Fabrication	6.6	Thyroid
		1.3	Whole-body
UF_6 Cylinder Rupture	UF_6 Production	0.4	Bone
UF_6 Cylinder Rupture	Fabrication	0.1	Bone
Criticality Incident	Reprocessing	0.04	Thyroid
UF_6 Loadout System Leak	Reprocessing	0.01	Bone
Storage Pool Cooler Leak	Reprocessing	0.01	Bone

No criticality incident has occurred in the United States during the processing of low enrichment uranium.[9] Equipment design, system parameters, and administrative procedures in fuel cycle facilities handling enriched uranium require that two independent errors be necessary for the occurrence of an accidental criticality, reducing the probability of an accidental criticality event to an extremely low value. The resulting dose from such a highly unlikely criticality incident is considerably greater than the annual dose from background radiation; however, it is lower than the maximum annual dose permitted by 10 CFR 20 for occupational exposure.

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[a] Very improbable, has never occurred with low enriched uranium.

[9] Although no such incident in the rest of the world is known to us, our information may be incomplete.

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A rupture or valve failure in a UF_6 cylinder is unlikely, but incidents of this nature have occurred in the past. An accident of this type could occur under varying conditions at a UF_6 plant, enrichment plant, or fuel fabrication facility. In estimating the off-site doses from this postulated accident, assumptions were made regarding the quantity released, the effectiveness of filters, and meteorological conditions. The calculated radiation doses are higher than the average annual dose from natural background radiation but are within the limits of 10 CFR 20 for unrestricted areas. The postulated accident at the UF_6 plant results in the highest off-site effects since it is assumed that the UF_6 cylinder malfunction occurs out-of-doors. Additionally, the fluoride release associated with the accident could result in some localized injury to plant life.

The accidents which were hypothesized for the mining, milling and waste management components of the fuel cycle do not result in significant off-site releases, or at worst entail limited decontamination efforts in the immediate vicinity of the site. The Federal facility for the interim storage of high level wastes will be designed to withstand all natural forces and man-created accidents so that there will be no significant release of radioactive materials to the environment outside of the facility.

It is estimated that 1.2 accidents involving truck shipments of non-enriched fuel cycle material could occur per thirty year lifetime of a model LWR. The low specific activity of the materials would limit the effects of a breach of containment to minor consequences. The likelihood of a criticality incident occurring during a truck shipment of fissile material is estimated to be infinitesimally small. Finally, it is estimated that 0.05 rail accidents involving the shipment of a high level wastes to a Federal storage facility might occur per thirty year lifetime of a model

LWR. Containers for high level waste must be designed and constructed to withstand accidents likely to be encountered in transport.

6. *Overview of Total Nuclear Fuel Cycle*

The environmental effects of the total nuclear fuel cycle have been estimated for mid-1972 and for the projected installed nuclear power generation capacity for 1979-1980. In mid-1972 approximately 10-12,000 MWe of nuclear electric generation capacity is estimated to be in operation in the United States. The projected installed nuclear electric generation capacity for 1980 is 140-150,000 MWe. Table S-6 summarizes industry demands and the number of plants for each fuel cycle step operating in 1972 and estimated required capacity and number of plants required to service the 1980 nuclear electric power generation industry. The environmental considerations for operations have been summarized in Tables 0-4, 0-5, 0-6, 0-7, 0-8, and 0-9. These data characterize the environmental effects of each individual fuel cycle plant. The environmental effects of the total fuel cycle may be obtained by combining the data in Table S-6 for the required number of plants with the corresponding information from Tables 0-4 through 0-9.

Uranium Mining

The existing uranium mining industry can produce about 30% more ore than is required by the nuclear electric generation capacity on-line today. By the end of the decade, the required mining rate must triple to meet the demand. Since the bulk of the known reserves are in New Mexico, Wyoming, Texas, Colorado and Utah, it is expected that the mines will be concentrated in that area. The only anticipated change in mining techniques is that a greater fraction of the ore mined in 1980 may come from underground

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TABLE S-6

TOTAL NUCLEAR FUEL CYCLE INDUSTRY

Types of Plants	1972 Plant Size Thousands of MT	1972 Annual Requirement Thousands of MT	1972 No. of Average Plants Required to Meet Power Demand	1980 (est.) Annual Requirement Thousands of MT	1980 (est.) No. of Average Plants Required to Meet Power Demand
Uranium Mines — Ore	250–750	4,500	10 (220)*	17,000	30–40
Uranium Mills — U_3O_8	0.5 – 1.1	9	12 (20)*	34	40–45
UF_6 Production — U	5–15	8	1+ (2)*	34**	3 Low Enriched Plants & 3-4 Natural Plants
Isotopic Enrichment SWU	7.5	5	1 (3)*	20	3
Fuel Fabrication — U	0.3 – 1.2	1.2	3+ (10)*	5.3	8–10
Fuel Reprocessing — U	0.3 – 1.5	0.2	1 (2)*	3	3–4

* Number in parenthesis is number of plants actually available.

** Including recycle of recovered U from reprocessing operations.

Nuclear Power Generation Basis: 10-12,000 MWe 1972
140-150,000 MWe 1980

mines, since a larger percentage of reserves are found at depths only amenable to underground mining.

Uranium Milling

The uranium milling industry is capable of supplying about twice today's nuclear power generation requirements of yellowcake. By 1980, the yellowcake demands are expected to quadruple. It is expected that the number of mills will more than double but it is likely that the technology employed will be similar to today's. The new mills are expected to be located in the Western States in the vicinity of mining operations.

UF_6 Production

It is anticipated that the 1980 requirements for UF_6 can be met by planned UF_6 conversion operations at the reprocessing plants and increases in the plant capacity of the existing facilities and by construction of several new UF_6 plants. No technological advance is forecast at this time.

Isotopic Enrichment

Planned improvements to the government owned complex of isotope enrichment plants will permit the existing plants to supply the amount of separative work required to service the 1980 installed nuclear electrical generation capacity. Since some of the electrical supply for the isotope separation plants is planned to come from nuclear power by 1980, it is estimated that there will be no increase in the gaseous chemical effluents from the enrichments plants despite a 70% increase in separative work capability.

Fuel Fabrication Plant

The fuel fabrication plant industry is presently serviced by 10 plants, some of which are not expected to be in use in

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1980. A total of 8 to 10 production plants, having a combined throughput of over 5000 MTU of fuel per year, will be required to service the 1980 industry. There are new processes under development in the conversion portion of the fuel fabrication step of the fuel cycle. These new processes are expected to reduce substantially most of the chemical process effluents from fuel fabrication.

Fuel Reprocessing

Three fuel reprocessing plants either exist or are under construction in 1972. It is expected that one additional plant will be built and operating in 1980 to meet the reprocessing load. No major technological advances for these plants are predicted.

Waste Management

The volume of other than high level wastes, i.e., those which may be buried in commercial burial grounds, will increase in about the same ratio as nuclear generation capacity. It is expected that the existing burial grounds will be adequate to handle the 1980 volume of wastes. At the present time and through 1980 high level wastes may be stored at the fuel reprocessing plant site as liquids and solids. This on-site storage does not impose significant environmental effects.

It is expected that by 1980 the Federal storage facility for storage of solidified high level wastes will be under construction. Hence, at some time after 1980, the high level wastes as solids will be transferred from the reprocessing plant to the Federal facility.

Transportation

At the present time, the transportation needs of the fuel cycle supporting the installed nuclear electric generation

capacity can be met by about 500 truck shipments per year on public highways. The movement of low specific activity material accounts for most of that total. By 1980, the number of truck shipments could exceed 7000, however, the use of rail transport may reduce this volume of highway movements. The amount of material shipped will continue to be an inconsequential fraction of the total transportation industry.

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F. IRRADIATED FUEL REPROCESSING

1. *Summary*

(a) General

Fuel reprocessing recovers the unused fissile material and separates the fission products from the spent fuel discharged by the power reactor. By the middle of the 1970's, three reprocessing plants, with an estimated combined annual capacity of 2700 MTU may be in operation in the United States. The three reprocessing plants are generally similar in regard to process technology, all using mechnical means for cladding destruction and adaptations of the Purex process for a part or all of the separations.[1]

The collective operation of the three plants, normalized to an annual capacity of 900 MTU/yr, is selected as the model reprocessing plant. This capacity is equivalent to the annual fuel requirements of approximately 26 model LWR's.

(b) Environmental considerations

The major environmental considerations associated with irradiated fuel reprocessing, normalized to a model LWR annual fuel requirement, are summarized in Table F-1 and as follows:[2]

TABLE F-1

Summary of Environmental Considerations For Irradiated Fuel Reprocessing (Normalized to Model LWR Annual Fuel Requirement)

	Total
Natural Resource Use	
Land (acres)	
Temporarily committed	3.9
Undisturbed area	3.7
Disturbed area	0.2
Permanently committed	0.03
Water (gallons x 10^{-6})	
Discharged to air	4.0
Discharged to water	6.0
Total	10.0
Fossil Fuel	
Electrical energy (MW-hr x 10^{-3})	0.45
Equivalent coal (MT x 10^{-3})	0.16
Effluents	
Chemical (MT)	
Gases	6.2
*SO_x	6.2
**NO_x	7.1
*Hydrocarbons	0.02
*CO	0.04
F^-	0.05
Liquids	
Na^+	5.3
Cl^-	0.2
$SO_4^=$	0.4
NO_3^- (as N)	0.2
Radiological (Ci)	
Gases (including entrained matter)	
Tritium (x 10^{-3})	15.7
Kr-85 (x 10^{-3})	350
I-129	2.4 x 10^{-3}
I-131	2.4 x 10^{-2}
Fission products	1.0
Transuranics	4 x 10^{-3}
Liquids	
Tritium (x 10^{-3})	2.5
Tu-106	4
Thermal (Btu x 10^{-9})	61

*Estimated effluent gases from combustion of equivalent coal for power generation.

**23% of total is estimated effluent gas from combustion of equivalent coal for power generation.

(1) Use of Natural Resources

The temporary land use of 3.9 acres comprises roughly 6% of the land use for the total fuel cycle. About 95% of this land use is a fenced in buffer zone and is not disturbed. Less than 0.03 acre per annual fuel requirement is permanently committed. The water use of 10 million gallons comprises about 3% of the water use for the total fuel cycle. Approximately 40% of the water is redistributed through evaporation. The electrical energy requirement of 450 MW-hr. comprises approximately 0.15% of the consumption of electrical energy in the total fuel cycle and is equivalent to the output of the model LWR for less than ½ hr.[3]

The fuel reprocessing component of the nuclear fuel cycle contributes significantly to the conservation of natural resources. The values recovered from the spent fuel can be measured in terms of about 30,000 MT of conserved uranium ore and bred and recovered fissile material worth $1.75 million per model LWR annual fuel requirement.[4]

(2) Effluents

The total radioactivity of airborne radioactive effluents from fuel reprocessing is large in comparison with the remainder of the fuel cycle. Assuming that all of the Kr-85 and tritium produced in the nuclear power plant fuel is released during the fuel reprocessing step, the estimated annual whole-body exposure at the site boundary from gaseous effluents is less than 1% of the natural background radiation throughout most regions of the country.[5] The release of radioiodine could result in an estimated maximum dose to the thyroid which is approximately 1% of the guideline limits recom-

mended by the International Commission on Radiological Protection. Moreover, the long-term build-up of Kr-85 in the atmosphere could eventually contribute approximately 80 man-rem annual whole body exposure, per model 1000 MWe LWR, to the entire world population of the northern hemisphere (4 billion people).

Nearly all of the fission products created in the nuclear reactor are removed from the uranium in the fuel reprocessing step. The activity of the fission products 150 days after discharge from the model reactor is reduced by radioactive decay to roughly 150 megacuries per model LWR annual fuel requirement.[6] The high-level wastes containing most of this radioactivity are stored as liquids in carefully designed, built and monitored tanks, within vaults, at the fuel reprocessing site for up to 5 years after separation. Eventually they will be converted to inert solids, and willbe shipped to a Federal interim storage facility within 10 years after separation, and thus isolated from the environment.[7]

Only one of the three plants comprising the irradiated fuel reprocessing industry discharges radionuclides to the watershed. According to measurements made in 1971 the maximum concentrations of tritium and Ru-106 released in this manner did not exceed 4% of 10 CFR 20 annual average concentration limits in off-site waters.[8]

Oxides of nitrogen and fluorides are the most significant gaseous chemical effluents from the fuel reprocessing plant. However, the estimated concentrations of NO_x at the site boundaries are more than two orders of magnitude below the 100 $\mu g/m^3$

EPA standard, and the predicted concentrations of fluorides are within the most restrictive State standard of 0.5 $\mu g/m^3$.[9] One of the plants comprising the irradiated fuel reprocessing industry releases chemicals to off-site waters. The incremental increase in concentrations in the receiving waters is roughly 1 ppm or less, a negligible amount for the chemical species involved.

Some heat, much of it originating from the decay of fission products in stored high level wastes, is discharged to the atmosphere. This thermal effluent amounts to slightly over 1% of that for the total fuel cycle.

(3) Accident Considerations

Fuel reprocessing plants are designed to assure adequate margins of safety to prevent accidents, and to assure that acceptable protection systems will function reliably to mitigate the consequences of accidents if they should occur as a result of multiple failures of systems or procedures that are provided to prevent accidents. A broad spectrum of accidents are analyzed, which range from minor process leaks or spills of radioactive material within the plant and/or its laboratory to credible major accidents such as, but not limited to, criticality incidents, solvent fires, hydrogen explosions, ion exchange resin fire, and typical accidents related to the handling and storage of radioactive materials. Credible accidents are treated as if they might occur during the life of the plant (irrespective of their low probability of occurrence) and the environmental consequence of the release of chemical or radioactive material that might result if the accident should occur is analyzed.[10]

The most significant accidental off-site exposure could result from an accidental criticality incident in these plants. If such an event were to occur, an individual at the site boundary could receive a dose to the thyroid of approximately 40 mrem.[11] In general, other postulated accidents could result in off-site exposures of 10 mrem to the bone of individuals near the site boundary via inhalation and ingestion of fission product and transuranic radionuclides dispersed into the atmosphere by accidental releases. It is significant to note, however, that in more than 25 years of fuel reprocessing experience using similar processes at government owned plants, there has been no accident that has resulted in the release of radioactivity to the off-site environs. Based upon the extensive safety measures instituted in new commercial facilities, at least as good a safety record is expected.

2. *Description of the Irradiated Fuel Reprocessing Industry*

Irradiated fuel reprocessing recovers usable fissile material from spent reactor fuel elements. During the operation of a reactor, the buildup of fission products and depletion of fissile material requires that the operator replace between one-fifth and one-third of the fuel elements annually and redistribute the other partially spent fuel in the reactor core. The discharged fuel elements contain about one-third of the uranium-235 that was in the fuel prior to irradiation, and the fissile plutonium that was produced from uranium-238 during irradiation. At present, the recovered uranium-235 is recycled in reactor reload fuel. In the future, the bred plutonium may be used as LWR reload fuel

or as fuel in liquid metal fast breeder reactors. At present, the plutonium is isolated and stored.

There are economic and technical considerations which favor recovery and recycle of fissile material from the spent fuel elements. The net value of the residual fissile material, allowing for costs associated with reprocessing, waste disposal, and transportation services, is approximately $50,000 per ton of irradiated fuel. Based on 35 metric tons of uranium reprocessed per year in support of a model 1,000 MWe LWR, the reclaimable fissile material has a net worth of about $1.75 million dollars. These economic savings are reflected in lower electric power costs. The recovered fissile material from an annual fuel requirement also represents the conservation of natural resources equivalent to approximately 30,000 MT of uranium ore.[12]

At present there are three fuel reprocessing plants in operation or being constructed in the United States. One plant has been in operation since 1966. Another is nearly completed and will be ready for operation in late 1972. The third plant is in an early stage of construction and scheduled for operation in late 1974. The three plants have a combined design capacity to meet the projected needs for fuel reprocessing services until late in the 1970's.[13]

The first commercial fuel reprocessing plant, the Nuclear Fuel Services (NFS) facility, can process irradiated light-water power reactor fuels at the rate of 1 MTU/day. In anticipation of the need for additional commercial services, NFS is giving consideration to increasing the plant's capacity to 900 MTU/year (3 MTU/day).

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The second commercial fuel reprocessing plant, the Midwest Fuel Recovery Plant (MFRP), will be ready for operation in late 1972. It has a design capacity of approximately 300 MTU/yr.

The Barnwell Nuclear Fuel Plant (BNFP), which will be the third irradiated fuel reprocessing plant, is in its early stages of construction. It is scheduled to begin operating in late 1974, and will have sufficient capacity to process 1500 MTU/yr.

Each of these plants is located on a relatively large, remote site. Site location, size and demography data for each plant are given in Table F-2. In general, the three fuel reprocessing plants are similar in respect to process technology. All plants utilize mechnical means for breaking up the fuel elements and chemical systems for recovering special nuclear material which are adaptations of the Purex process, for which the technology and risks are well defined. However, specific methods applied for mechanically disassembling the fuel elements, dissolving fuel materials, and applying separation technology to recover fissile materials differ somewhat from plant to plant.

Spent fuel element assemblies are received at the reprocessing plant via truck or rail in heavily shielded shipping casks. The assemblies are spaced arrays of sealed tubular rods containing UO_2 pellets which have been partially transformed into PuO_2, fission product oxides, and gases by irradiation. The tubes encapsulating the fuel are made of zircaloy or stainless steel.

After storage to permit short half-life radionuclides to decay (150 days), the fuel elements are

TABLE F-2

IRRADIATED FUEL REPROCESSING PLANTS
SITE DATA AND DEMOGRAPHY[14]

Plant and Location	Site Size, Acres	Population Density people/sq. mi.	Nearby Population Centers		
			City	Population	Distance, Miles
Nuclear Fuel Services, West Valley, N.Y.	3350	90	Buffalo	463,000	28
			West Valley	<1,500	4
Midwest Fuel Recovery Plant — Morris, Ill.	890*	150	Morris, Ill.	8,000	8
			Joliet, Ill.	79,000	15
			Aurora, Ill.	74,000	27
Barnwell Nuclear Fuel Plant — Barnwell, S.C.	1700**	35	Barnwell, S.C.	4,500	7.5
			Aiken, S.C.	16,000	26
			Augusta, Ga.	60,000	33

*Adjacent to the Dresden nuclear reactor site of 2,230 acres.

**Adjacent to AEC Savannah River Plant exclusion area.

chopped into short pieces, exposing the metal oxides. The metal oxides are leached by hot nitric acid, leaving behind the chopped tubing (hulls). The hulls are soaked in hot nitric acid and water to assure that essentially all of the uranium, transuranics and fission products have been removed. The nitric acid solution, containing uranium, transuranics and fission products, is adjusted chemically and processed through solvent extraction and ion exchange systems. These process steps separate the fission products, uranium, and plutonium, from each other. The purified uranium product is converted to uranium hexafluoride (UF_6) and is shipped to the gaseous diffusion plant for reenrichment. The purified plutonium product will be stored pending conversion to PuO_2 for use in future plutonium recycle or breeder reactor fuel elements.

Each of the plants has gaseous, liquid low-level and solid wastes as illustrated in Table F-3. All gaseous effluents will be discharged to the atmosphere via off-gas treatment and filtering systems, which are designed to remove over 99.9% of the radioactive iodine gas and the radioactive fission product and transuranic particulates. The plants release krypton 85 to the environment at rates ranging from 0.1 to 0.4 Ci/sec. Moreover, the MFRP and BNFP facilities will also discharge tritium oxide in water vapor to the atmosphere at rates of 0.007 to 0.018 Ci/sec.[16] About 40% of the tritium from the NFS plant is released, with other treated low-level wastes, to a creek which eventually flows into Lake Erie about 39 miles from the site. NFS is the only fuel reprocessing plant that adds radioactivity to the liquid effluent from the plant. The

TABLE F-3

IRRADIATED FUEL REPROCESSING PLANTS

MAJOR WASTE SYSTEMS[15]

Plant	Gaseous Effluents	Liquid Wastes		Solid Wastes[3]
		High-Level	Other Than High-Level	
NFS	To atmosphere via Iodine Scrubber, HEPA filters, 61 meter stack	Stored onsite as neutralized liquid in tanks in vault[1]	Tritium and Ru-106 controlled release to creek	Stored onsite in drums in impervious clay deposits
MFRP	To atmosphere via Iodine Scrubber, sand filter, 91 meter stack	Converted to solid. Stored onsite in containers under water in storage basin	Stored onsite in tanks in vault as immobile salt cake	Stored onsite in underground lined vault
BNFP	To atmosphere via Iodine Scrubber, HEPA filters, 100 meter stack	Stored onsite as acidic liquid in tanks in vault[2]	Stored onsite in tanks in vault	Stored onsite in underground concrete drums

(1) Plans underway to add tanks for storage of high-level liquids in acidic conditions with ultimate conversion to solids for transfer to a Federal storage facility.

(2) Plans for solidification of high-level liquid wastes for transfer to a Federal storage facility.

(3) All facilities ship other than high-level solid wastes to commercial burial grounds for long-term storage, with the exception of hulls and fuel hardware which are stored onsite as indicated above.

MFRP and BNFP will discharge cooling water effluent which under normal operating conditions will not contain added radioactivity.

Each plant has provisions for complete containment of high-level liquid wastes in high integrity tanks in vaults or as an immobile solid as shown in Table F-3. The plans vary somewhat, but all result in total retention of the high-level wastes with no release to the environment. Within five years all high-level liquids will be converted to solids and within ten years will be transferred to a Federal storage facility for long-term confinement.[17] Solid waste materials such as hulls and fuel hardware are stored onsite in underground vaults, concrete containers or in impervious soil.[18] Other low-specific activity solid wastes are packaged and shipped to commercial burial grounds for long-term storage. There will be essentially no release of solid radioactive wastes to the off-site environment from any plant.

Plans are under way or under consideration for all three of the plants to process the recovered uranium values to hexafluoride to be recycled through the gaseous diffusion plants. Uranium hexafluoride production results in some non-radioactive chemical effluents of fluoride bearing compounds. The recycled uranium can represent as much as one-third to one-fourth the amount of natural feed to the enrichment operation, so that the potential impact of the fluorination operation at the reprocessing plant corresponds to a fraction of the total environmental impact associated with UF_6 production.

Pending development of a future market for the plutonium product recovered by reprocessing nuclear power reactor spent fuel, the fuel reprocessors tentatively plan to store the plutonium product for the utilities as part of their services. The plutonium product can be stored safely in special containers and facilities specifically designed for this purpose. The storage of plutonium product at the reprocessing site has been considered in licensing safety evaluations and with respect to the environmental impact of irradiated fuel reprocessing as a whole.

By 1975, the annual quantities of plutonium recovered by reprocessing nuclear power reactor spent fuel will be in the range of 2-3 metric tons; by 1980 about 15 metric tons; and will increase more rapidly thereafter.[19] The feasibility of using about 3 weight percent plutonium in a mixed plutonium-uranium oxide fuel for LWR's has been demonstrated.[20] However, the prospective utilization of such plutonium recycle fuel is somewhat uncertain since the actual timing and the extent to which the recovered plutonium will be recycled is an economic matter to be considered by each utility. Moreover, although several firms have indicated plans to provide production-scale, mixed oxide fuel fabrication plants by 1975 or 1977, the present capability for fabricating such fuel is limited. Accordingly, pending development of the plutonium recycle economy, limited means for storing the recovered plutonium product inventory will be provided at the three reprocessing plants.

The New York State Atomic and Space Development Authority (ASDA) has constructed a plu-

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tonium storage facility, for the above purpose, at its Western New York Nuclear Service Center, West Valley, New York.[21] This facility is specifically designed to eliminate the possibility of any significant radiation exposure, criticality incident, or other accidents that might be related to the storage of plutonium in sealed containers. It can store 2 metric tons of plutonium as nitrate in a nitric acid solution. The plutonium nitrate solution is contained as follows: (a) in a 10-liter polyethylene bottle, (b) that is sealed within a 304 L stainless steel 14-gauge tubular capsule, (c) which is inserted in an eight-inch thick annulus of reinforced concrete with seven-inch thick reinforced concrete bottom and top cover disks, and (d) all of the above are contained within a sealed steel drum. Approximately 1000 such containers can be stored in this facility. Similarly, General Electric Company and Allied-Gulf Nuclear Services plan initially to store Class 1 shipping containers of plutonium nitrate solution within respective protective areas of the MFRP and BNFP.[22]

As the rate of plutonium generation increases due to additional LWR's being placed in operation, other more economical means could be provided for the storage of the larger inventories of recovered plutonium product. At that time, bulk quantities of plutonium nitrate solutions could be stored in vessels within confinement structures specifically designed and constructed for that purpose, or the plutonium nitrate solution could be converted to plutonium dioxide, a solid, which can be sealed in containers and stored in vaults specifically designed and constructed for that purpose. The timing for the start of use of recovered plutonium and the

rates for either recycle or storage will be dependent upon an analysis of many changing factors. At this time it is not feasible to make firm projections concerning use of recycle plutonium in LWR's beyond the indication that some recycle may be accomplished by the end of this decade.

3. *Description of the Irradiated Fuel Reprocessing Model*

The mechanisms for discharge of effluents from the three fuel reprocessing plants differ somewhat. For this reason, and because it is likely during the remainder of this decade that these facilities will comprise the entire fuel reprocessing industry in the U.S., the collective operation of the three plants is chosen as the basis for the fuel reprocessing model.

The model plant is defined to have a capacity of 900 MTU/yr and the environmental releases and other related considerations are taken to be one-third of the aggregate for the entire industry. This capacity is equivalent to the annual fuel requirements of approximately 26 model LWR's. The model plant occupies a 2,000 acre site and operates for at least 20 years.

4. *Environmental Considerations*

a. Use of Natural Resources

(1) Land

Nearly all of the 2,000 acre site is only temporarily committed. Of this, approximately 100 acres are disturbed by plant construction and 1,900 acres remain an undisturbed exclusion area.[33]

At the end of its useful life, if necessary, the facilities can be dismantled and much of the area reclaimed. The area occupied by the plant itself and

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waste disposal areas probably could not be restored to its original condition. A conservative estimate is that an area of approximately 15 acres would be permanently committed.

(2) Water

Operations at the model plant will require water at the rate of approximately 600 gpm. This is equivalent to 10 million gallons of water per model LWR annual fuel requirement. Of this, about 6 million gallons is returned to the surface water and about 4 million gallons is released to air via evaporation and drift from the cooling tower.[24]

(3) Other

The power required to operate the model reprocessing plant is approximately 1.3 MWe. The energy required to produce the annual fuel requirement for the model LWR is 450 MW-hr, which corresponds to the consumption of 160 MT of coal at a fossil fuel fired plant producing this energy.[25]

b. Effluents

(1) Chemical

(i) Gaseous

The chemical off-gas effluents from irradiated fuel reprocessing are oxides of nitrogen, fluoride (associated with UF6 production), and combustion products from the plant's steam generators. The quantity of NO_x released from the model reprocessing plant is approximately 185 MT annually.

Extensive analyses have been made of the expected concentrations of airborne chemical

effluents at the site boundary for the individual fuel reprocessing plants. The calculated site boundary NO_x concentrations are in the range of 0.1-1.0 $\mu g/m^3$. These concentrations are orders of magnitude lower than the EPA standard, an arithmetic mean concentration of 100 $\mu g/m^3$.[26]

Fluoride in reprocessing plant off-gases originates almost entirely from uranium hexafluoride production. The quantity of fluoride released from the model plant is estimated to be approximately 1 MT annually. The calculated fluoride concentrations at the site boundaries are below the most stringent state standard for fluoride release, an arithmetic mean concentration of 0.5 $\mu g/m^3$ (State of Washington).[27]

(ii) Liquid

Only one of the three plants releases significant quantities of chemicals in liquid effluents. Table F-4 gives the most significant of these effluents. The estimated release rates are normalized to the capacity of the model reprocessing plant. This table also gives the maximum incremental increase in concentrations in offsite receiving waters. The incremental concentration increases are negligible.[28]

TABLE F-4

IRRADIATED FUEL REPROCESSING PLANTS
CHEMICALS IN LIQUID EFFLUENTS

Species	Annual Release* MT/yr	Incremental Increase in Concentration in Receiving Water Δppm
Sodium	137	1.3
Chloride	6.3	0.06
Sulfate	11.3	0.1
Nitrate (as Nitrogen)	4.8	0.04

*Normalized to the annual 900 MTU/yr capacity of the model plant.

(2) Radiological

(i) Gaseous

An irradiated fuel reprocessing plant releases airborne effluents containing krypton-85, tritium and minute quantities of radioactive iodine, other fission products and transuranic particulates which might pass through the off-gas treatment and filter systems. Table F-5 summarizes the estimated activity released annually by the model plant, and it relates this activity to the potential maximum exposure to individuals at boundaries of the plants' exclusion areas. These exposure estimates are a) uncorrected for shielding that would be provided by clothing and buildings, b) uncorrected for occupancy time in the area and, c) assume that a child ingests milk contaminated with radioiodine from a family cow that grazes at the boundaries of the exclusion areas.[29]

On these bases, the annual exposure could be 0.95 mrem to the whole-body, 1.0 mrem to bone,

TABLE F-5

IRRADIATED FUEL REPROCESSING PLANTS
GASEOUS RADIOACTIVE EFFLUENTS[31]

Radionuclide	Exposure Mode	Annual Release* (Ci/yr.)	Exposure** (mrem/yr.)
Kr-85	External irradiation of whole body	9,000,000	0.2
	Irradiation of skin		13.5
H-3	Internal irradiation of whole-body	400,000	0.65
I-129	Irradiation of thyroid	0.060	8.7
I-131	Irradiation of thyroid	0.60	6.0
Other Fission Products	Irradiation of body	25	<0.10
Transuranics	Irradiation of bone	0.10	0.15

*Normalized to the annual 900 MTU/yr. capacity of the model plant.

**Estimated maximum exposure at the site boundaries of the three plants comprising the industry.

15.5 mrem to the thyroid, and 14 mrem to the outer layer of skin. Thus, the whole-body exposure is less than 1% of that from natural background radiation.[30] The exposures projected for skin, thyroid and bone represent approximately 0.5%, 1.0%, and 0.05%, respectively, of the guideline limits recommended by the International Commission on Radiological Protection, Report No. 9.

(ii) Liquids

High level liquid wastes containing more than 99.9% of the nonvolatile fission products are concentrated for storage on site in specially built, contained and monitored tanks for a

maximum of 5 years. This is followed by conversion to inert solid and, after a maximum on-site storage time of ten years, eventual transfer to a Federally designated disposal site. At 150 days after discharge from the reactor, the activity of the irradiated fuel has decreased by radioactive decay to about 4 megacuries of fission products per MTU or 150 million curies per annual fuel requirement. In addition to the fission product content, there will be approximately 3.5 kilograms of plutonium and 350 kilograms of uranium in the wastes from an annual fuel requirement. The total quantity of high-level waste from an annual fuel requirement can be converted to a solid weighing approximately 1.4 to 2.3 MT.[32]

Of the three facilities comprising the irradiated fuel reprocessing industry, only the NFS plant release radionuclides in liquid effluents. This results in an equivalent annual release from the model reprocessing plant of approximately 65,000 curies of tritium and 100 curies of Ru-106. At the NFS site, the concentrations of H-3 and Ru-106 at the point of release from the holding pond exceed the maximum permissible concentrations given by 10 CFR 20 and require dilution in receiving streams, which pass through the site. Receiving stream measurements in 1971 indicated that the concentration of tritium never exceeded 10^{-4} μCi/ml and that the maximum concentration of Ru-106 was 4×10^{-7} μCi/ml. These maximum levels are less than 4% of the limits in 10 CFR 20. The annual average concentrations of tritium and

ruthenium would be expected to be much less than the observed maxima in the receiving stream. Taking into account that the stream is not a potential source of drinking water there is little potential for radiological effects on human beings from this liquid effluent stream.[33]

(iii) Solid

The volume of solid wastes, other than high level wastes, from a model LWR annual fuel requirement is summarized in Table F-6. The undissolved fuel element hulls, containing trace quantities of uranium, plutonium, and fission products, and other fuel element parts

TABLE F-6

IRRADIATED FUEL PROCESSING PLANT SOLID WASTES OTHER THAN HIGH LEVEL LAND BURIAL PER ANNUAL FUEL REQUIREMENT[34]

	Volume
Undissolved fuel element hulls	350–700
Other fuel element parts and discarded equipment	140–230
Laboratory waste, small tools, gloves and clothing	190–1000

will be stored or buried on-site in recoverable form and may eventually be shipped to a Federal repository. Discarded equipment will be decontaminated prior to disposal. Laboratory wastes, small tools, gloves, and clothing may be buried on-site or at a commercial burial ground.

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(3) Thermal

The rate of heat dissipation from the model plant will be about 185 million Btu/hr. This is equivalent to 61 x 10^9 Btu per annual fuel requirement. The heat will be discharged to the atmosphere via the off-gas stack, a cooling tower and a cooling pond. All liquids released offsite will be cooled to ambient temperature prior to release.[35]

(c) Accident Considerations[36]

At fuel reprocessing plants, operations having a potential for the occurrence of equipment failures or accidents which could disperse significant amounts of radioactive contaminants are performed within shielded process cells. These cells are designed to maintain adequate confinement capability in the event of accidents or natural phenomena much more severe than has been experienced historically for such plants or in the locality of the plant. It is expected that during the life of the plant, some equipment failures will occur. Accordingly, monitors are provided in the system to detect process or equipment failures and to provide corrective action automatically, or signal a need for corrective action. Moreover, the plant is designed to cope with such failures or accidents, and the cells and equipment are designed so that they can be decontaminated for the repair or replacement of equipment. A ventilation system provides assurance that the contaminated air from within the cells, or from any inadvertent releases within the plant, will be routed through high efficiency filters that remove airborne radioactive particulate before the ventilation air is discharged to the stack. In summary, a fuel reprocessing plant is designed to (a) assure adequate margins of safety to prevent accidents, (b) cope with potential accidents, and (c) mitigate the consequences of accidents if they should occur

as a result of multiple failures of systems or procedures that are intended to prevent accidents.

These plants are analyzed with respect to a wide spectrum of credible accidents and the consequence that might result if an accident should occur. While major equipment failures, or spills of radioactive materials within the plant, might disrupt operations and cause the plant to shut down for cleanup and repair, it is not expected that such occurrences would result in the release of significant amounts of radioactivity so as to contaminate the offsite environs. That is, radioactive contamination would be confined within the process cell, or within the process building, and little if any might escape to contaminate the area in the vicinity of the plant, within the plant's exclusion area. Only a few accidents involving radioactive materials have occurred in existing plants, and none resulted in contamination beyond the immediate vicinity of the plant. The experience gained from these few accidents has resulted in improved safety procedures and features so that the probability of similar occurrences in the future is extremely low. Some examples of the types of accidents that might occur in fuel reprocessing plants, which would have little, if any, discernible impact on the offsite environs, are listed below. This is followed by a brief summary of the more significant potential accidents, irrespective of their low probability of occurrence, and an assessment of the possible consequences if they should occur as a result of multiple failures of systems or procedures that are intended to prevent their occurrence.

The following are examples of types of accidents that are postulated with respect to the analysis of irradiated fuel reprocessing operations. Those listed below are not expected to result in discernible contamination of the environs offsite, nor discernible exposure to the public.

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Abnormal Event	Potential Consequence
Drop fuel cask into cask unloading pool	Possible rupture of fuel pins and release of fission gas to atmosphere; contamination of storage pool water.
Fuel element hung up in air during transfer to shear	Possible overheating and rupture of fuel pins; release of fission gas to atmosphere.
Ignition of zirconium fires	Small fire of short duration — little, if any, damage.
Rapid chemical reaction in dissolver	Vessel pressurized, seals blown fission gases released to atmosphere; cell contaminated.
Leak in recovered acid line	Contamination of cell or pipe trench in area of leak.
Leak of any vessel or line confining radioactive material	Contamination of cell or pipe trench; transfer material to spare tank space, decontaminate cell and equipment, repair failure or replace equipment.
Excessive entrainment radioactivity in evaporator overheads	Contamination of recovered acid or effluents, which must be recycled.
Failure of an iodine scrubber	Reduced iodine removal efficiency of backup systems; shutdown plant until adequate efficiency restored.
Filter failure	Detectable increase of radioactivity in stack effluent; shutdown plant and replace filter.
Loss of ventilation zone control differential-pressure	Possible migration of radioactivity from controlled area to limited control area; correct deficiency and decontaminate building area.
Solvent fire	May plug filter, contaminate cell and ventilation exhaust ducts could require extensive cleanup of cell and ducts, and replacement of filter, while plant shutdown for repairs.

Plutonium or waste concentrator explosion	Blowback of air, contamination of cell and possibly adjacent limited control area near cell; could require extensive cleanup of cell and adjacent building area, while plant shutdown for repairs; possible airborne particulate resulting in offsite exposures of less than 1 mrem.
HF tank leak	Air concentration of toxic HF could be lethal to unprotected persons in vicinity of tank; not discernible offsite.

Table F-7 summarizes the possible consequences of the more significant potential accidents, if such accidents could occur, and is followed by a brief discussion of each accident. Even such major accidents, if they should occur, are not expected to result in radiological exposures that would have any discernible effect on the environment.

TABLE F-7
ESTIMATED RADIATION EXPOSURE AT SITE PERIMETER RESULTING FROM POSTULATED ACCIDENTS

Accident	Organ of Greatest Exposure	Organ Dose (rem)
Criticality incident	Thyroid	0.04
Ion exchange resin fire	Lung	0.001
UF_6 loadout system leak	Bone	0.01
Storage pool cooler leak	Bone	0.01
Fuel assembly rupture	Thyroid	0.002

A criticality incident in a reprocessing plant is an unlikely event because the design of equipment and process limitations prevent such incidents. Safe spacing is ensured in storage basins by physically spacing the fuel elements in safe geometry even when dropped. Process systems and controls are designed to prevent assembly of an unsafe array. Nevertheless, a criticality accident is postulated, in which a burst of 10^{18} fissions is assumed. This

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yield is approximately an order of magnitude greater than that which has been experienced, on the average, in past accidents. It is further assumed that all noble gases and halogens (or halides) are discharged from the plant stack without taking credit for filters, and that the airborne fission products arrive at the site boundary 15 minutes after the burst. It is estimated that the whole body exposure from gamma radiation to an individual is approximately 3 mrem, and that the dose to the thyroid from radioiodine is 40 mrem.

Similarly, the design of equipment and process limitations prevent the occurrence and limit the consequences of a postulated ion exchange resin fire. However, in postulating a hypothetical ion exchange resin fire, it is assumed that 128 liters of resin, containing 30 gm of plutonium per liter, are contained in the column section that ruptures and burns. On the basis of known filter efficiences and the results of burning experiments with metallic plutonium, it is estimated that approximately 10^{-3} of the plutonium, as insoluble plutonium oxide, passes the filter and is expelled through the stack. The resultant dose to the lung of an individual at the site boundary is estimated to be 1 mrem.

In a postulated UF_6 loadout system leak, 350 kg of UF_6 is assumed to escape as a result of a cylinder valve break at the loading temperature. The specific alpha activity of uranium in fuel irradiated to 33,000 MWd/T is approximately 1.4 Ci/kg. If it is assumed that the UF_6 bypasses the filter and is expelled as UO_2F_2 via the stack, the resultant dose to the bone of an individual at the site boundary is estimated to be approximately 12 mrem.

A leak in the storage pool cooler was postulated. The pool water activity is assumed to be approximately 5×10^{-3} μCi/ml. On the basis of Savannah River contaminant com-

position observations, Ce-144 is chosen to represent the potential hazard of the mixture of contaminants. It is assumed that 1.5 gal/min of cooling water is vaporized during the course of one week. Inspection programs assure detection within one week, and a higher rate of leakage would be detectable earlier. Assuming release outside the containment at ground level in the building wake, the estimated dose to the bone of an individual at the site boundary is approximately 10 mrem.

A fuel assembly rupture is postulated, in which all of the fuel pins in one element rupture under 20 feet of water in the fuel storage pool. One element contains about 0.45 MT of irradiated uranium. The rupture of all of the fuel pins in the element would release approximately one-third of the Kr-85 inventory and 3% of the iodine inventory, i.e., that which had diffused from the fuel into the void space in the fuel element. The gases in the void space would escape and bubble to the surface of the fuel storage pool. However, most of the iodine would be absorbed in the fuel storage pool water. On the basis that one-third of the Kr-85 and 0.1% of the iodine escape to the surface of the fuel storage pool and are exhausted to the atmosphere, the estimated exposure (primarily to the thyroid) of an individual at the site boundary is approximately 2 mrem.

The storage of high-level radioactive wastes in stainless steel tanks within stainless steel lined vaults, with redundant cooling systems, multiple sources of cooling water supply, spare tanks, and elaborate monitoring and alarm systems is deemed to represent a degree of containment as being essentially accident proof.[37] Moreover, these confinement systems are designed and constructed with a high degree of quality assurance to ensure their capability to withstand accidents, earthquake and tornado effects.[38] For these reasons, the probability of an accidental release of radioactivity is considered to be extremely low and thus there would not be any significant release to the environs.

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7. 10 CFR 50, Appendix F.
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9. See the first three documents listed under note 2 above.
10. See note 1 and the first three documents listed under note 2 above.
11. *Draft Detailed Statement on Environmental Considerations Related to Midwest Fuel Recovery Plant.*
12. See note 4 above.
13. See note 1 above.
14. See note 1 and the first three documents listed under note 2 above.
15. See note 1 and the first three documents listed under note 2 above.
16. See the first three documents listed under note 2 above.
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25. General Electric Company, "Final Safety Analysis — Midwest Fuel Recovery Plant."

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26. See the first three documents listed under item 2 above and letter, J. F. Wing to W. L. Smalley.

27. See the first three documents listed under note 2 above.

28. Nuclear Fuel Services, Inc., "Environmental Report No. 10."
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29. See the first three documents listed under note 2 above, and ORNL-4451.

30. *Environmental Quality.*

31. See documents listed under note 1, the first three documents listed under note 2, and ORNL-4451.

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36. All accident analyses are taken from US AEC *Draft Detailed Statement of Environmental Considerations of the Midwest Fuel Recovery Plant*, Appendix C.

37. South Carolina State Legislature Committee Report, *Report of the Committee to Study the Establishment of Plants or Facilities for the Recovery of Nuclear Fuel and the Storage of Waste Nuclear Materials* (1972).

38. See the second and third documents listed under note 1 above.

G. RADIOACTIVE WASTE MANAGEMENT

1. *Summary*

(a) *General*

The radioactive wastes resulting from the nuclear fuel cycle can be categorized as high-level and other than high-level. High-level wastes, generated at fuel reprocessing plants contain fission products separated from fissile material recovered from irradiated fuel. Other than high-level wastes result from operations involving production of UF_6, fuel fabrication, and fuel reprocessing. These include all wastes, regardless of concentration or specific activity, which are not designated as high-level.

Appendix F of AEC regulation 10 CFR 50 requires that the inventory of high-level liquid waste at the fuel reprocessing plant be limited to that produced in the prior 5 years and that it be converted to solid form and be transferred to a Federal repository within 10 years of its separation from the irradiated fuel. The establishment of a Federal repository for long-term storage of high-level wastes is under consideration. Starting about 1980 and until a long-term repository can be established, the Federal government plans to provide an engineered structure facility for interim storage of high-level wastes. This interim facility will be designed with capability for storage of wastes for a 100-year period. The Federal government will have responsibility for care and maintenance over any site at which high-level waste is stored. Control must be maintained as long as any waste is stored in a facility.

Radioactive wastes other than high-level are buried in near-surface shallow trenches, usually in the containers in which they are shipped. There is no intent to recover

the wastes once they are buried. There are 6 commercial land burial sites in the United States authorized to receive and bury other than high-level wastes.

Land used for commercial land burial is owned or controlled by the States. In the event of default or abandonment of the site by the commercial operator, the State is obligated to provide care and maintenance of the site to assure its dedication to radioactive waste burial and to assure it is not used for other purposes.[1]

(b) *Environmental Considerations*

(i) Resource Use

The waste generated as a result of fuel cycle operations will require the commitment of less than 0.2 acre for the storage of both high-level and other than high-level wastes resulting from the model LWR annual fuel requirement.

(2) Effluents

No effluents to the off-site environment are expected to result from burial of waste classified as "other than high level." The Federal repository will safely isolate the high level waste material from the environment.

(3) Accidents

Possible accident effects at commercial land burial facilities would normally be confined to low level contamination of the immediate area of the accident and would not result in release of significant amounts of radioactive material to the environment. However, if there were a release to areas outside the facility, the contaminated areas would be surveyed for radioactivity and decontaminated.

The engineered facility for high-level wastes will be designed to prevent any release of radioactive material either from natural phenomena or man-created accidents.[2] The high-level solid wastes are immobile, stable material, sealed in containers. Should an accident result in the failure of a waste container, the trace amount of radioactivity in the cooling media would be readily detected. The failed waste container would be identified and re-sealed. The cooling media will be routinely monitored and treated to prevent a release of radioactivity to the environs.

2. *Description of the Radioactive Waste Management Industry*

Radioactive waste generated during fuel cycle operations is divided into two categories, high-level and other than high-level. High-level waste is defined in Appendix F, 10 CFR 50, as the aqueous wastes resulting from the operation of the first cycle solvent extraction system, or equivalent and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuels. All other waste, regardless of its source, falls into the other than high-level category and may be sent to a commercial land burial facility for disposal.

(a) *Disposal of Other Than High-Level Wastes*

At the present time, there are six commercial land burial facilities which are authorized to receive and bury other than high-level wastes. Five of the sites are on land owned by States and the other site is on land owned by the Federal government and leased to the State. Commercial land burial facilities must be located on land which is owned by either a State or

Federal government.[3] The purpose of this requirement is to assure long-term control of the site in the event of default or abandonment of the site by the commercial operator. It is intended that, after radioactive wastes are buried at the site, the land not be used for any other purpose. The States have the obligation for perpetual care and maintenance of land burial sites to assure their dedication to waste burial and to assure that they are not used for other purposes. Authorization to operate a commercial land burial facility is based on an analysis of nature and location of potentially affected facilities and of the site topographic, geographic, meteorological, and hydrological characteristics, usage of ground and surface waters in the general area, which demonstrate that buried radioactive waste will not migrate from the site.[4]

Monitoring wells are maintained at each burial site and are sampled periodically to determine if there has been any migration of radioactivity. In addition, air and vegetation samples are taken around the site and analyzed for radioactivity. Should any sample reveal an increase in the concentration of radioactive material in an aquifer above that measured prior to commencement of burial operations and it is determined that the radioactivity originated in the burial ground, its significance must be analyzed, corrective actions developed, as appropriate, and the entire matter reported. Corrective actions are subject to approval by the Atomic Energy Commission or an Agreement State and additional corrective measures can be required as a regulatory agency deems appropriate.

To date, there have been no reports of migration of radioactivity from commercial burial sites. In the unlikely event that there would be such a finding, sev-

eral courses of action could be taken. These include: (1) a halt to burial operations, (2) removal of the radioactive material from the burial area in which the radioactivity originated, (3) grouting of the site from which the radioactivity originated, or (4) other such procedures which might be necessary, depending on the extent of migration of radioactivity from the site.

Existing commercial land burial facilities are located in the States of Washington, Nevada, Illinois, Kentucky, South Carolina, and New York. Currently, about 1,000,000 cubic feet of packaged radioactive waste materials are buried per year.[5] It has been estimated that the annual volume will increase to about 2,000,000 cubic feet by 1975 and 4,000,000 cubic feet by 1980.[6]

An average burial trench at a commercial burial site is about 300 feet long, 30 feet wide, and 20 feet deep and has a volume of 180,000 cubic feet.[7] The volume is not completely utilized since there are voids between packages and between packages and earth fill. Assuming 100,000 cubic feet of waste can be stored in a trench, approximately 10 trenches are needed per year to accommodate the current rate of burial of radioactive wastes. The total land area of the six burial sites is about 600 acres.[8] Assuming 50% usage of available land for trenches, this land area would accommodate over 1400 average burial trenches and would provide for burial of 140,000,000 cubic feet of packaged waste.

The commercial land burial sites are located in rural, sparsely settled areas or in virtually uninhabited areas such as the Armagosa Desert in Nevada.[9] The sites themselves are generally isolated so that public access to them is limited. The areas in which wastes are buried are enclosed by fences and access to the sites is carefully controlled by the site operator.

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The prime operations at a commercial land burial facility are the receipt, temporary storage, and burial in trenches of packaged radioactive wastes. The packages that are shipped to the burial facilities must meet the requirements of the Department of Transportation (DOT) and the Atomic Energy Commission (AEC) for transportation of radioactive material.[10]

The packages are normally buried as received with no reprocessing or repackaging of package contents. However, in some cases, the primary package containing the waste is shipped in a reusable overpack or secondary container which may be required by DOT regulations for shipment of the particular materials involved. In those instances, the primary package is removed from the reusable overpack before burial of the primary package.

The suitability of a site for burial of radioactive wastes depends on the geological and hydrological characteristics of a site and its ability to retain the radioactive material so that there will be no migration of the radioactive material from the burial site. No credit is taken for containment provided by the packages once they are buried. The purpose of the packages is to provide ease of handling and minimization of personnel exposure and to prevent loss of the radioactive material to the surroundings prior to burial.

The volume of packaged radioactive waste consigned to a commercial land burial facility by the various steps in the fuel cycle is relatively small. There is no packaged waste buried at commercial facilities from operations in the mining, milling, and enrichment steps.

During production of UF_6, waste consisting of such things as rags, sweepings, boxes, piping, etc. contaminated with uranium is generated. The average concentration of the waste is low (a few thousandths of a microcurie per gram) and the volume of packaged waste sent to a commercial land burial facility for disposal amounts to a few thousand cubic feet for the model LWR annual fuel requirement.[11] Fuel fabrication operations generate wastes similar to those generated by UF_6 production facilities.

Fuel reprocessing operations generate wastes consisting of general laboratory waste, small tools, gloves, clothing, etc. contaminated with fission products and/or fissile materials.

The volume of waste generated as a result of reprocessing the spent fuel from a model LWR annual fuel requirement ranges from 200 to 1000 cubic feet, depending on the compaction or other volume reduction methods utilized at the fuel reprocessing facility.[12]

(b) *High-Level Waste Disposal*

Appendix F, 10 CFR 50, requires that the inventory of high-level liquid waste at a fuel reprocessing plant must be limited to that generated in the prior five years. The liquid waste must be converted to dry solids and transferred to a Federal repository no later than ten years following separation of fission products from irradiated fuels. The solids will contain a variety of fission products and will ultimately be in a non-reactive form.

The spent fuel from a model LWR processed annually in a fuel reprocessing plant produces approximately 1000 gallons of radioactive liquid waste which,

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when converted to a solid, weighs approximately 1.4 – 2.3 MT.[13] Assuming that this waste is in the form of calcined solids diluted with twice its volume of inert material, it would occupy a volume of approximately 100 cubic feet.

It was planned to construct a Federal repository in a salt mine for long-term geological storage of solid high-level wastes by the mid 1970's. However, subsequent events have deferred the site selection and construction of such a repository.

The present alternative plan is to design and construct a near-surface engineered storage facility capable of safely storing high-level radioactive waste containers for 100 years or until such time as a permanent Federal repository can be established.[14] The Federal government will have responsibility for the care and maintenance for the engineered storage facility which will be used for storage of high-level waste and and the future repository for permanent storage of such waste. The intended life of the engineered storage facility is 100 years: however, the Federal government will have the obligation for care and maintenance as long as any waste is stored in the facility.[15] Although a repository for long-term geologic storage of high-level waste is intended to isolate the waste from man and the biosphere, the Federal government will have the obligation to maintain control over the site in perpetuity.

At this time, the plans for the engineered storage facility are in the development stage and it is not possible to discuss this program in specific terms.[16] The engineered facility will be designed so that solid high-level wastes can be stored without danger to the health

and safety of man and with no unacceptable impact on the environment. The use of man-made facilities for storage of waste requires a greater degree of human surveillance and maintenance than would geologic storage since such facilities are subject to deterioration by the forces of nature and possible deliberate or inadvertent damage by man. Plans will be included in the design of the man-made facilities for the removal of the stored material at some future date to locations that do not require continued surveillance.[17]

When specific plans are developed for either an engineered storage facility or a pilot repository in a geological formation, at that time detailed environmental statements will be issued for each such facility.

3. *Description of Model Waste Handling Facilities*

(a) *Land Burial Facility*[18]

A model land burial facility for other than high-level wastes consists of 100 acres of land located in a rural, sparsely settled area. The site location is near a highway so that there is reasonable access to the site. The site characteristics are such that the ground water is well below the bottom of the deepest trench. The precipitation in the site area is low so that flooding of trenches and leaching of buried radioactive material is minimal. The soil provides good ion exchange characteristics to minimize percolation of radioactivity which may be leached from the solid waste to the ground water. There is no nearby use of ground water or well water downstream from the site. The site and its vicinity have the characteristically slow water movement through the soil in a direction in which there is little or no land use.

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Buildings on the site provide space for offices, a laboratory, temporary storage of packaged radioactive wastes, and other waste handling as may be necessary, such as solidification of low concentration liquids. The storage space is also used for storage of vehicles, earth moving equipment, fork lifts, etc., which are necessary for preparation of trenches and handling of packages containing radioactive wastes.

The portion of the site in actual use is fenced so that access to trenches and buildings is prevented. The fence also serves to minimize entry by area wildlife.

The operator of a site has a program for environmental monitoring. This program includes sampling of air, water, and vegetation to determine migration, if any, of radioactive material from the actual location of burial. Records are maintained of the monitoring results.

Trenches which are completed are cared for to minimize erosion and are marked to specify the contents. Packages in partially filled trenches are covered over with earth frequently to minimize access to the waste, provide shielding during placement of packages in the trench, and to minimize entry of water into the trench.

The model facility keeps temporary storage of packages to a minimum. Packages are placed in a trench and covered with earth as soon after receipt as possible.

(b) *High-Level Waste Storage Facility*[19]

A model high-level waste storage facility will be located on government-owned land in a remote, sparsely inhabited area.

The model facility will have storage buildings which are massive structures designed and built to meet a

service life-time of 100 years, to provide a protective barrier against the forces of man and nature, and to provide shielding against the radiation from the stored wastes. The structures will be built and maintained so that they may be kept in serviceable condition beyond the design lifetime.

The facility structures are planned to be in modular form which can accommodate the high-level waste generated as the result of fuel reprocessing. It is estimated that the annual high-level wastes from 250 model LWR's will be stored in one module. The volume of high-level solid wastes resulting from the annual fuel requirement of a model LWR is about 100 cubic feet. Additional modules can be constructed as needed.

About 1,000 acres of land may be committed for the overall site. Only 30 acres are needed for the initial module and supporting structures; however, additional land is needed to accommodate future growth of the facility and to provide a buffer zone around the site. The portion of the site in use will be surrounded by a fence to limit access to the site.

The model facility is planned to have equipment appropriate for the opening and unloading of shipping casks and placement of canisters containing the solid high-level wastes in the storage buildings. Special features will be designed into the storage buildings to protect against all credible accidents. The structures and storage facilities and equipment will be designed to assure that, even if all services including the power are lost, radioactive material will not be released to the environment. The structures will be designed and built to withstand natural forces such as severe storms,

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tornadoes, earthquakes, and floods, and all credible actions by man.

4. ***Environmental Considerations***

(a) ***Use of Natural Resources***

(1) Land Use

The volume of other than high-level packaged radioactive waste which is generated during fuel cycle operations is variable and difficult to estimate. However, the total quantity of radioactive material contained in such wastes is small and amounts to only a few curies. It is estimated that the nuclear fuel cycle activities required to produce the annual fuel requirement for a model LWR will generate about 10 curies of radioactive material in other than high-level wastes. This activity will be contained in wastes sent to commercial land burial facilities for disposal. Assuming an average concentration of radioactivity in the waste of 0.025 microcurie per gram and a waste density of 1 g/cc, the total waste volume will be approximately 14,000 cubic feet. Assuming no further compaction of the waste, the final volume of packages containing the waste could approximate 20,000 cubic feet per annual model LWR fuel requirement.

If the waste is packaged in 55-gallon drums, about 3,000 drums would be needed. If the drums are placed in rows 5 deep and 10 wide in an average 30 foot wide burial trench, 60 rows will be required. Since the drums are 2 feet in diameter, a total area of 3,600 square feet of land surface will be required. This is less than 0.1 acre.

For the solid high-level waste which would be stored in a Federal engineered storage facility, it is estimated that the waste from the annual fuel requirement of a model LWR would be about 100 cubic feet and would be stored in 10 containers. It is estimated that about 2500 waste containers would be stored in the initial module of the engineered structure storage facility on a site occupying about 30 acres. Thus about 0.1 acre of land is required for the interim storage of the annual high-level wastes from the model LWR fuel requirement.

Based on the above estimates, the land area required for disposal of all radioactive wastes from manufacture and reprocessing of a model LWR annual fuel requirement is less than 0.2 acre.

(2) Water and Other Resources Use

There is very little use of water or other natural resources involved in normal operations involving the burial or storage of solid packaged wastes generated as a result of fuel cycle operations.

(b) *Effluents*

(1) Chemical and Radiological

The normal operations involved in the burial of "other than high level" radioactive wastes in solid form are not expected to result in any effluent releases to the off-site environment. The Federal repository will safely isolate the high level waste material from the environment.

(2) Thermal

Due to the very low concentrations of radioactive materials in the other than high-level wastes that

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result from nuclear fuel cycle operations, there is essentially no heat release to the environment from these wastes.

The storage of packages containing solid high-level wastes at an engineered facility will result in the release of a small amount of heat. The wastes in each package (about 10 cubic feet) will generate about 2-5 kw of heat, depending on the elapsed time since the material was first created in the reactor.[20] During transfer and storage of packages in the facility, some heat transfe medium will be used to dissipate the heat from the sealed containers.

(c) *Accident Effects*

There have been no accidents at burial grounds under Federal or State jurisdictions that resulted in offsite environmental effects. Some minor accidents have occurred involving materials not utilized in any fuel cycle.

Accidental opening of an other than high-level waste package prior to burial and release of the package contents could occur, however, at a commercial land burial facility. Normally the scattered waste materials would be confined to the fenced facility and the impact on the environment would be negligible. However, even if it is assumed that as much as $\frac{1}{3}$ of the waste contained in a 55-gallon drum is released to the unrestricted area, the effect on the environment would be insignificant. The volume of a 55-gallon drum is approximately 2×10^5 cubic centimeters. Using the assumption made previously of a waste concentration of 0.025 microcurie per gram and density of 1 g/cc, the total amount of radioactivity involved is about 1.7 millicuries. If the waste were uniformally dispersed over an area of one acre, the

concentration of the radioactive material would be about 0.04 microcurie per square foot or 4×10^{-5} microcurie per square centimeter. Dispersion over a greater area would result in a proportionally lower concentration. Much of the dispersed material would be in the vicinity of the site which is normally uninhabited and unused. Recovery of the bulk of the scattered waste could easily be accomplished. Radiation surveys could be made and the area decontaminated.

With respect to the engineered structure facility for high-level wastes, the major credible accident would be loss of cooling with concomitant heating and possible failure of the package in which solid high-level waste is contained. The facility will be designed to protect against this type of accident. The facility will be designed to withstand all credible natural forces and man-created accidents so there will be no release of radioactive material outside the facility. The high-level solid wastes are immobile, stable material, sealed in containers. The presence of trace amounts of radioactivity in the cooling media would identify the failure of a waste container. The cooling media will be routinely monitored and treated to preclude any release of radioactivity to the environment. A failed waste container would be repackaged.

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REFERENCES

1. See for example letter from State of Nevada Department of Conservation and Natural Resources to USAEC, "Lease Agreement State of Nevada — Nuclear Engineering, Co.," USAEC Docket 27-10 (Feb. 15, 1972).
2. United States Atomic Energy Commission, *Management of Commercial High Level Wastes,* SECY-2371 (March 17, 1972) p. 20.
3. 10 CFR Part 20, Section 20.302.
4. *Ibid.*
5. United States Atomic Energy Commission, *The Nuclear Industry-1971,* WASH-1174-11 (1971) p. 154.
6. *Ibid.*
7. United States Atomic Energy Commission, Land *Burial of Solid Radioactive Wastes: Study of Commercial Operations and Facilities,* WASH-143 (1968) Table 2, p. 33.
8. *Ibid.*
9. *Ibid.*
10. 10 CFR Part 71, 49 CFR Parts 173 and 177.
11. Allied Chemical Corp., "Application for Source Material License, Amendment," USAEC Docket 40-3392, Feb. 17, 1971.
12. Allied-Gulf Nuclear Services, "Barnwell Nuclear Fuel Plant Applicant's Environmental Report," USAEC Docket No. 50-332 (Nov. 5, 1971) Table 3.6-3, p. 76.
13. *Management of Commercial High-Level Radioactive Wastes,* p. 6.
14. *Ibid.,* pp. 13, 16-17.
15. 10 CFR Part 50, Appendix F.
16. *Management of Commercial High-Level Wastes,* pp. 17-20.
17. *Ibid.,* p. 18.
18. The model presented in this section is based on information in *Land Burial of Solid Radioactive Wastes.*
19. The model presented in this section is based on information in *Management of Commercial High-Level Wastes,* pp. 17-20.
20. *Management of Commercial High-Level Wastes,* p. 19.

OVERVIEW OF TOTAL NUCLEAR FUEL CYCLE

The preceding portions of this survey deal with the aspects of the nuclear fuel cycle as related to an individual model LWR. To provide additional perspective on the environmental effects of the nuclear fuel cycle, an overview of the combined effects from the total nuclear fuel cycle industry has been estimated and is included in this section. Since the size and nature of the industry is dependent to a great extent upon the time frame of the evaluation, two time periods have been selected for this overview. The time frames utilized are as follows:

A. Approximately the present date (mid 1972); and

B. The end of this decade (1979-1980).

In order to evaluate the environmental effects of the nuclear fuel cycle, it is first necessary to establish the size of the industry that it serves. At the present time, about 10-12,000 MWe of nuclear electric generation capability is estimated to be operational in the United States. The existing nuclear fuel cycle industry has capabilities that in general are in excess of the requirements for this size power generation capacity. Table O-1 summarizes the capabilities of the present day nuclear fuel cycle industry and relates these capabilities to the needs of today's power generation capacity.

TABLE O-1

NUCLEAR FUEL CYCLE INDUSTRY

1972

Type of Plant	Plant Average Annual Capacity Thousands of MT	Total Industry Annual Capacity Thousands of MT	Approx. Annual Demand from Nuclear Power Generation Thousands of MT	No. of Plants Available	Approximate No. of Plants Rqd to Meet Power Needs
Uranium Mines — Ore	250–750	8200	4500	220	10
Uranium Mills — U_3O_8	0.5–1.1	19	9	20	12
UF_6 Production — U	5–15	19	8	2	1+
Isotopic Enrichment — SWU	6	10	5	3	1
Fuel Fabrication — U	0.3–0.5	3	1.2	10	3+
Fuel Reprocessing — U	0.3	0.15*	0.2	2	1

*One plant in operation for about 6 months

Although other fuel cycle schemes are competing with the LWR concept, it appears that the prevalent method for generation of electrical power by nuclear energy will continue to be light water cooled and moderated uranium fueled reactors through the end of this decade. It is known that some utilities have plans to utilize bred plutonium in the form of mixed oxide LWR reload fuel in the latter part of the decade. Plans are under way for production facilities for this type of fuel which may be in operation during the latter half of the decade and small amounts of this fuel could be available in the period 1976-1978. Based on these plans, production quantities of fuel could be expected to be manufactured by the end of the decade and it appears that perhaps as much as 5% of the total fuel in use by 1980 may be of the mixed oxide (Pu-U) variety. Another fuel cycle is the high temperature gas cooled concept (HTGR). This scheme has not been demonstrated in large scale commercial size units to date. Several commercial size power generation facilities have been committed and are planned to be operational by the end of this decade or the early part of the next. It is estimated that this component of the nuclear power generation capability will be less than 5% (2-3%) of the nation's capacity by 1980. An additional concept for future application is the liquid metal fast breeder reactor (LMFBR). However, it is not expected that any significant application of this concept will be in commercial use by 1980. A commercial scale demonstration unit of this scheme is planned to be in operation early in the next decade. In summary, it appears that the nuclear generation of electric power for the remainder of this decade will be predominantly by the use of LWR's fueled with uranium dioxide and that this concept will constitute 90-95% of the industry throughout this period.

Numerous estimates of the size of the nuclear electric generation industry have been made and have required

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frequent revisions as a result of changing conditions and schedules. A consensus of these estimates indicate that approximately 140-150,000 MWe may be installed and on line by the year 1980. Based upon this projection, the requirements of the nuclear fuel cycle to service the power generation industry have been estimated and are shown in Table O-2.

TABLE O-2

PROJECTED

NUCLEAR FUEL CYCLE INDUSTRY

1980

Type of Plant	Plant Size Thousands of MT	Annual Requirement Thousands of MT	No. of Average Plants Required to Meet Power Demands
Uranium Mines — Ore	250-750	17,000	30-40
Uranium Mills — U	0.5-1.1	34	40-50
UF_6 Production — U	5-15	34*	3 Low Enriched Plants & 3-4 Natural Plants
Isotopic Enrichment — SWU	7.5	20	3
Fuel Fabrication — U	0.3-1.8	5.3	8-10
Fuel Reprocessing — U	0.3-1.5	3	3-4

*Including recycle of recovered U from reprocessing operations

Nuclear Power Generation Basis: 140-150,000 MWe

Uranium Mining

1972

Domestic uranium mines presently produce about 6.3 million MT of ore per year having an average assay of about 0.2% U_3O_8. These mines have a total rate capacity of about 8.2 million MT per year. About 70% of the ore is mined in New Mexico and Wyoming with an additional 17% mined in Colorado and Utah. Thus, only about 70% of the ore produced is required to meet the demands of today's nuclear power industry.

Over 98% of the uranium produced results from open pit and underground mining. About one-half of the total ore is produced in 29 open pit mines with individual capacities up to 700,000 MT per year and 193 underground mines with individual capacities up to 230,000 MT per year produce most of the remainder. The environmental considerations for an open pit mine producing 480,000 MT per year are listed in Table O-3.

1980

By the end of the decade, the nuclear electric generation industry will require the mining of about 17 million MT of uranium ore annually. The bulk of the known uranium reserves are in New Mexico, Wyoming, Texas, Colorado, and Utah. It is expected that mining methods will be similar to those used today except that a larger percentage of the ore may be mined using underground mining techniques since a large percentage of the known reserves occur at depths greater than 400 feet. The environmental effect of the uranium mining industry at the end of the decade may be represented by 30-40 mines similar to that shown in Table O-3. However, the average amount of land use per mine is

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expected to decrease as the percentage of ore mined by underground methods increases.

TABLE O-3

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS FOR OPEN PIT URANIUM MINE — 4.8 x 10^5 MT/YR

Natural Resource Use	
Land (acres)	
Temporarily committed	290
Permanently committed	10
Overburden moved (MT x 10^{-6})	14
Water (gallons x 10^{-6})	
Discharged to ground	650
Fossil Fuel	
Electrical Energy (MW-hr. x 10^{-3})	1.3
Equivalent coal (MT x 10^{-3})	0.5
Effluents	
Chemicals (MT)	
Gases	
SO_x	19
NO_x	5
Hydrocarbons	0.05
CO	0.1

Uranium Milling

1972

At the present time, there are approximately 20 mills operational in the United States with a combined capacity of about 17,000 MT of U_3O_8 annually. Of these plants, 70% are within the output range of 500-1100 MT/yr. of U_3O_8. From Table O-1 it is indicated that today's nuclear power industry requires only 9,000 MT per year. Thus, it is apparent that approximately one-half of the 20 operational uranium mills would be adequate for today's power generation industry. These mills are located in sparsely populated areas in close proximity to mining operations principally in the States of New Mexico, Wyoming, Colorado, and Utah. The environmental considerations from a 1000 MT/yr. U_3O_8 uranium milling industry may be characterized by 20 mills each having environmental effects similar to those noted in Table O-4.

1980

The nuclear electric generation industry by the end of this decade will require the operation of about 40-45 uranium mills. It is estimated that these facilities will employ technology very similar to that for today's plants with minor technological improvements which will tend to minimize some of the environmental considerations. Since the bulk of the known uranium reserves are centered in the far western States of New Mexico, Wyoming, Colorado, and Utah, it is expected that new milling facilities will be located in those areas near companion mining operations and in sparsely populated relatively arid regions. Thus, the uranium milling industry at the end of the present decade may be represented by 40-45 operating units, each having effects on the environment as listed in Table O-4.

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TABLE O-4

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS URANIUM MILL — 1000 MT/Yr. U_3O_8

Natural Resource Use	
Land (acres)	
Temorarily committed	50
Permanently committed (limited use)	250
Water (gallons/yr. x 10^{-6})	
Discharged to air	3600
Fossil Fuel	
Electric Energy (MW-hr/yr. x 10^{-3})	15
Equivalent Coal (MT/yr. x 10^{-3})	3
Natural gas (scf/yr. x 10^{-6})	380
Effluents	
Chemical (MT/yr.)	
Gases	
SO_x	200
NO_x (40% from natural gas use for process heat)	87
Hydrocarbons	5
CO	1.7
Liquids (x 10^{-3})	
Tailing Solutions	1300
Solids (x 10^{-3})	
Tailings	500
Radiological (curies/yr.)	
Gases (including airborne particulates)	
Rn-222	460
Ra-226	0.1
Th-230	0.1
U-natural	0.2
Liquids	
U & daughters	11
Solids	
U & daughters	6700
Thermal (Btu/yr. x 10^{-9})	390

UF_6 Production

1972

The nuclear generation industry currently requires about 8,000 MT of uranium as uranium hexafluoride (UF_6). The two facilities in operation at the present time have capacity considerably in excess of this level. It is probable that either existing plant could meet this demand without difficulty. Thus, to meet present day requirements, essentially only one UF_6 production plant is required. The environmental considerations for a 5000 MTU/yr. UF_6 production plant are summarized in Table O-5.

1980

Plans are under way at the present time to initiate the recycle of uranium recovered from the fuel reprocessing step. It appears that each of the fuel reprocessing facilities may have a UF_6 production capability for recycle of recovered uranium values before the end of the decade. The requirements for UF_6 by the end of this decade are estimated to be approximately 34,000 MTU as UF_6. It is estimated that this requirement could be made up from the combined capacities of the planned UF_6 production facilities at the reprocessing plants amounting to 2700 MTU and facilities for production of UF_6 from natural uranium. This expanded demand could be met by the expansion of existing plants to double or triple their present capacity and additional new plants could be added so that a total of 3-4 facilities for the production of natural UF_6 could be operational by the end of the decade. At this time, no significant technological advances can be projected that will affect environmental considerations from these plants. Accordingly, it is projected that UF_6 production plants in 1980 will resemble in most respects the plants of today's era but may be about double their size. Therefore, the industry can be represented by a combination of about 3-4 natural uranium hexa-

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fluoride plants, each twice the size of the unit summarized in Table O-5 and three smaller plants handling recovered slightly enriched uranium.

TABLE O-5

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS URANIUM HEXAFLUORIDE PRODUCTION PLANT — 5000 MTU/Yr.

Natural Resource Use	
Land (acres)	
Temporarily committed	1400
Permanently committed	10
Water (gallons/yr. x 10^{-6})	
Discharged to air	100
Discharged to water bodies	1100
Total	1200
Fossil Fuel	
Electrical Energy (MW-hr/yr. x 10^{-3})	58
Equivalent Coal (MT/yr. x 10^{-3})	21
Natural Gas (scf/yr. x 10^{-6})	850
Effluents	
Chemical (MT/yr.)	
Gases	
SO_x	800
NO_x (25% from natural gas for process heat)	280
Hydrocarbons	2.2
CO	5.5
F	3.0
Solids	1000
Radiological (curies/yr.)	
Gases	
Uranium	0.4
Liquids	
Ra-226	0.7
Th-230	7.4
Uranium	0.7
Solids (buried)	
Other high level	7.7
Thermal (Btu/yr. x 10^{-9})	830

Isotopic Enrichment

1972

The nuclear generation industry at the present time requires about 5,000 MT of SWU to satisfy its present enrichment requirements. Today's industry is supplied with enrichment services from the complex of the three AEC owned and contractor operated gaseous diffusion plants. Essentially any one of the existing plants operated independently would be adequate to meet this demand. However, since all three installations are operated in a combined fashion, it is difficult to isolate the environmental considerations of an individual plant. Accordingly, the environmental effects of the total three-unit complex as it is operating today are summarized in Table O-6.

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TABLE O-6

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS FOR URANIUM ENRICHMENT COMPLEX

Natural Resource Use	1972 10.5 MT SWU	1980 18 MT SWU
Land (acres)		
Temporarily committed	1500	1500
Permanently committed	nil	nil
Water (gallons/yr. x 10^{-6})		
Discharged to air	8100	12,000
Discharged to water bodies*	10^6	1.8×10^6***
Fossil Fuel		
Electrical Energy (MW-hr/yr. x 10^{-3})	28,500	41,000
Equivalent Coal (MT x 10^{-3})	10,000	10,000***
Effluents		
Chemical (MT/yr.)		
Gases		
SO_x	400,000	400,000
NO_x	100,000	100,000
Hydrocarbons	1000	1000
CO	2500	2500
Particulates	100,000	100,000
F	45	45
Liquids		
Ca^+	490	880
Cl	740	1130
Na^+	740	1130
$SO_4^=$	490	880
Fe	36	65
NO^3	240	450
Radiological (curies/yr.)		
Gases		
Uranium	0.2	0.3
Liquids		
Uranium	1.8	3.1
Thermal (Btu/yr. x 10^{-9})**	290,000	420,000

*power plant cooling

**67% at power plants

***about ⅓ of electrical power from nuclear stations in 1980.

1980

It is planned to increase the capability of the existing three-plant complex from about 10,000 MT SWU to 22-27,000 MT SWU. This increased capability will be achieved without the construction of major new gaseous diffusion facilities and will be accomplished primarily by improving and upgrading present units. The modifications will involve installation of improved equipment and increased utilization of electrical power. Thus, no new processing plants are required to meet the projected 1980 industry demands and accordingly the land requirement for this portion of the fuel cycle will remain essentially constant to the end of the decade. It should be noted that the utilities providing power to the gaseous diffusion complex have made commitments for the installation of significant amounts of additional power generation capacity. Included in these commitments are major nuclear generation stations amounting to 8-10,000 MWe of capacity. It is estimated that this switch over from essentially all coal burning power plants to some nuclear powered stations could effectively result in about one-third of the power requirements for the gaseous diffusion complex being provided by nuclear generation facilities. The industry demand in 1980 will require operation of the gaseous diffusion complex at a level of 20,000 MT SWU. Assuming that the plants will be modified to incorporate current improved technology, this level of operation will require approximately 4,700 MW of electrical power. On the basis that two-thirds of the power for this operation could be provided by coal burning power stations, the amount of power supplied by coal fired stations in 1980 will amount to 3,200 MW which is about constant with today's situation. Thus, despite the fact that the separative work capability of the complex will be increased by about 70% and its power

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rating will be upgraded by about 50%, the major gaseous chemical effluents, which come from the combustion of coal, attributable to the isotopic enrichment function may remain constant with today's levels. The use of natural resources such as water (assuming once through cooling at the power plants) and liquid chemical and all radiological effluents might be expected to increase at a rate essentially equivalent to the increased separative work capability. A summary of the environmental considerations of the enrichment complex in 1980 is listed in Table O-6.

Fuel Fabrication

1972

The fuel requirements for the nuclear generation industry are approximately 1200 MTU. This capacity is met by 10 existing plants, a number of which have limited capacity and which conduct only a portion of the processes required to produce fuel assemblies for reactors. In fact, only two of the facilities that are in operation at the present time are large scale production plants which have capacities similar to that considered for the model plant in this statement. The environmental considerations for a 900 MTU fuel fabrication plant are summarized in Table O-7.

TABLE O-7

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS FOR 900 MTU/Yr. FUEL FABRICATION PLANT

Natural Resource Use	
Land (acres)	
Temporarily committed	100
Permanently committed	nil
Water (gallons x 10^{-6})	
Discharged to water	135
Fossil Fuel	
Electrical Energy (MW-hr. x 10^{-3})	44
Equivalent Coal (MT x 10^{-3})	16
Natural Gas (scf x 10^{-6})	94
Effluents	
Chemical (MT)	
Gases	
SO_x	600
NO_x	160
Hydrocarbons	1.6
CO	4
F	0.1
Liquids	
N as NH_3	220
N as NO_3	140
F	10
Solids	
CaF_2	680
Radiological (curies)	
Gases	
Uranium	0.005
Liquids	
Uranium	0.5
Th-234	0.3
Solids (buried)	
Uranium	0.2
Thermal (Btu x 10^{-9})	230

1980

Plans are under development for the expansion of the present production facilities and for the design and construction of numerous new production type fuel fabrication facilities to replace some of the smaller units now in operation. It is estimated that by the end of the decade, 8-10 production facilities could be in operation to meet the annual requirements of over 5,000 MTU of fuel per year. In the case of fuel fabrication, technological advances have been under development for several years which could have a significant effect on environmental effects. The development of the technology for the dry conversion of UF_6 to UO_2 has been in progress for some time and it is anticipated that this technique will be reduced to practice by the end of the decade with a substantial reduction of both gaseous and liquid chemical effluents that are associated with process operations. This process improvement will essentially eliminate the chemical effluents of ammonia and fluoride. Thus, this industry can be characterized in 1980 by 8-10 plants similar to the one summarized in Table O-7 with the elimination of most of the process chemical effluents.

Fuel Reprocessing

1972

One plant for the reprocessing of commercial nuclear power reactor fuel has been in operation for about six years. This plant is currently shut down for extensive modifications and has operated for only a portion of 1972. A second plant is nearing the operational stage and is planned to be handling irradiated fuel during 1973. An additional plant is under construction and there are plans for its operation by the middle of the decade. At the present time there is little demand for reprocessing services

as noted in Table O-1 and much of that demand has been met by the one plant operating for part of a year and the ability to store fuel at that plant is planned to be operational in 1973. The environmental effects of a 900 MTU/yr. reprocessing plant are shown in Table O-8.

1980

It is estimated that three fuel reprocessing plants may be operational before the end of the decade with a combined capability of processing 2,700 MTU annually. A fourth plant is being planned for start-up late in this decade or early in the 1980's. It appears that these plants could be adequate to meet the power industry needs. Thus, the industry in 1980 can be characterized by 3-4 plants similar to the plant outlined in Table O-8.

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TABLE O-8

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS OF 900 MTU/YR FUEL REPROCESSING PLANT

Natural Resource Use	
Land (acres)	
Temporarily committed	2000
Permanently committed	100
Water (gallons x 10^{-6})	
Discharged to air	100
Discharged to water	150
Fossil Fuel	
Electrical Energy (MW-hr. x 10^{-3})	12
Equivalent Coal (MT x 10^{-3})	4
Effluents	
Chemical (MT)	
Gases	
SO_x	160
NO_x	185
Hydrocarbons	0.5
CO	1
F	14
Liquids	
Na^+	140
Cl^-	0.5
$SO_4^{=}$	14
NO_3 (as N)	5
Radiological (curies)	
Gases (including entrainment)	
Tritium (x 10^{-3})	405
Kr-85 (x 10^{-3})	9000
I-129	6 x 10^{-2}
I-131	6 x 10^{-1}
Fission products	26
Transuranics	1 x 10
Liquids	
Tritium (x 10^{-3})	65
Ru-106	100
Thermal (Btu x 10^{-9})	1600

Waste Management

1972

At the present time, there are six commercial land burial sites in operation in the United States. The total area of these sites is approximately 600 acres. Not all of this land is available for actual burial of wastes since some of the land area is needed for support facilities, pre-burial storage, etc. The land available for burial of wastes is adequate for the current generation of radioactive waste by fuel cycle industries. The current requirement for the waste generated in the fuel cycle is about 1.0-1.5 acres annually. At the present time, there is no requirement for a Federal storage facility for long-term storage of solidified high-level wastes generated as a result of fuel reprocessing operations.

1980

By 1980, it is estimated that the nuclear electric generation capacity will increase to about 12 times present capacity. On this basis, about 12 to 18 acres will be needed for burial of radioactive waste generated by fuel cycle facilities. This would be well within the capacity of the currently existing commercial land burial sites and it does not appear that additional sites would be required. By 1980, it is anticipated that a Federal storage facility will be under construction for storage of solidified high-level wastes. The high-level wastes, in a combination of liquid and solid forms, could be stored at the fuel reprocessing facilities without significant environmental effects until the Federal repository is completed and available for storage of wastes during the next decade.

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Transportation

1972

The nuclear power generation industry is still small and amounts to 10-12 annual operating units. The transportation needs of the supporting fuel cycle are shown in Table O-9. The movement of low specific activity material constitutes almost all of these shipments. The heat and weight in any shipment and the relatively small number of shipments will essentially have no appreciable effect on the environment. The estimated population exposure for onlookers, people along the route and transportation workers is 2.8 man-rem.

1980

By the end of the decade the size of individual plants may increase and certainly the number of plants will greatly increase. As production levels increase at a particular site, the transportation requirements may favor switching from the truck to the rail mode of movement.

Typical of this change might be the shipment of natural UF_6 in cylinders from the UF_6 production plant to the gaseous diffusion plant. Despite the fact that the mass handled in transportation should increase by a factor of about 12-15, the quantities involved will continue to be of little consequence with regard to the total transportation industry. A summary of the shipments is shown in Table O-9. The estimated population exposure is 35 man-rem. It is assumed that this 35 man-rem exposure will be distributed among at least 600,000 people giving an average exposure of 0.06 mrem/person/year. The dose due to the average natural background radiation is about 130 mrem/person/year.

TABLE O-9

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS FOR TOTAL NUMBER OF PACKAGES TRANSPORTED ANNUALLY

Step-Material Transported	1972 Total No. of Truck Shipments	1980 Total No. of Truck Shipments
1. Mine to Mill — Ore	40,000	500,000*
2. Mill to UF_6 Production — U_3O_8	140	1,800**
3. UF_6 Production to Enrichment — Natural UF_6	260	3,300**
4. Enrichment to UO_2 Plant — Enriched UF_6	60	750**
5. UO_2 Plant to Fabrication — Enriched UO_2	180	1,400**
6. Solid Wastes to Federal Storage — Fission Products	12(Rail)***	150(Rail)***

*Almost all of these shipments are made on privately owned land.

**Number of shipments may be reduced by shipments from larger processes being switched from truck to larger rail shipments.

***These packages, one (1) per shipment, will be stored at the reprocessing site until after 1980 when the Federal storage and repository facilities are planned for use.

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STATE OF NEW YORK

COMMENTS

on the

"Environmental Survey of the Nuclear Fuel Cycle"

by the

U. S. Atomic Energy Commission,

Fuels and Materials, Directorate of Licensing

Issued November 1972

1. General Comment — It is suggested that the "Survey" provide a complete evaluation of the environmental costs of the nuclear fuel cycle. To do this, the "Survey" should include environmental costs of shipment of fuel to the power plant and spent fuel and other radioactive wastes from the power plant and the environmental costs of the operation of a 1,000 MW plant. This supplemental information could be presented in an appendix to the "Survey." The information presented in this proposed appendix should include, on an annual basis, the environmental considerations of those portions of the nuclear fuel cycle for the "model light water reactor" that are controlled directly by the applicant and subsequent owner of a nuclear power plant. The delineation of responsibilities would afford greater assurance that each facet of the fuel cycle is given due consideration by industry, the utilities and government.

It should be made clear, if this is done, that each environmental report by the applicant must include the needed detail for this portion of the nuclear fuel cycle that will have a direct impact on the environment around the proposed site.

For example: The survey provides little information on the numbers and types of irradiated fuel and high level radioactive waste shipments to various known fuel reprocessing plants and waste disposal areas. It is suggested that the projected amount and type of each material planned to be shipped by either rail or truck be stated in the Survey for each A.E.C. Compliance Region. Such information would be helpful to state government agencies responsible for regulating the transportation of hazardous commodities.

2. General Comment — It would be desirable to have an environmental survey for fossil fuel cycles to allow a comparison of the total environmental costs of a nuclear power plant and a fossil fired power plant.

3. General Comment — In regard to many of the tables in the report, the use of a negative sign for exponents of 10 is confusing. It is recommended that the exponential be included in the unit rather than as a multiplier of the unit. For example, in Table S-3, Page S-14, under Land: Overburden moved (MT x 10^{-6}) — 2.7; instead use: Overburden moved (MT) — 2.7 x 10^{6}.

4. Page S-3 Fig. S-1 — Reprocessing should show an output to plutonium storage which is described on page F17.

5. Pages S-11 and S-12 — The "Survey" identifies the most commonly used standards that were the basis for evaluating the environmental impact of the effluents. A brief discussion should be included on FRC recommendations such as the "as low as practicable" concept. In addition, the "Survey" should refer to the radiological standards in the "Greenbook" ("Water Quality Criteria". F.W.P.C.A., April 1, 1968) that is used in the "Survey" as the standard for chemical wastes.

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6. Page S-16 Table S-3 — Liquid effluents — Sr-90, Cs-137 and I-129 are omitted — these isotopes have been released in liquid effluents from NFS.

Solids from manufacturing and reprocessing will be sent to commercial burial sites and should be included in the table.

7. Page S-30 — Gaseous releases refer to minute quantities of radioiodine. The Survey should specifically consider I-129 and provide quantitative information rather than the general wording "minute." The reconcentration of I-129 in milk as measured around the NFS facility should be described.

In addition, the potential for exposure of the population as a result of gaseous releases of tritium and its introduction via air transport into surface public water supplies should be considered.

8. Page S-31 — In referring to measured 1971 offsite concentrations of liquid releases, Sr-90 and Cs-137 and other isotopes should be included. The dilution factor of the receiving streams should be provided and the concentration in the effluent from the plant should be included.

9. On pages S-33, and F-14, the report indicates that the fuel element hulls and other contaminated fuel element parts will be buried on site at the reprocessing facility in retrievable form and may eventually be shipped to Federal storage facility. The report should discuss minimum requirements and present practices by the industry in terms of retrievability of hulls.

10. On page F-4 under Effluents, it is assumed that all of the Kr-85 and tritium produced in the nuclear power plant

fuel is released during the fuel reprocessing step. Estimated annual whole body exposure at the site boundary from gaseous effluents is less than 1% of the natural background. The release of radioiodine could result in an estimated maximum dose to the thyroid which is approximately 1% of the guide line limits recommended by the International Commission on Radiological Protection. This assumption and estimate apparently is based on the statement on page F-13 which indicates that gaseous effluents will be discharged to the atmosphere thru off-gas treatment and filtering systems which are designed to remove over 99.9% of the radioactive iodine gas. There should be clarification as to whether the 99.9% removal factor will be a requirement of the United States Atomic Energy Commission.

11. Page F-6 — Regarding discharge to the watershed from the one plant, there is no reference to radionuclides such as Sr-90, Cs-137, and I-129 nor is there an adequate discussion of the dilution factor in the onsite streams that was required to bring the offsite concentration of H-3 to 4% of 10CFR20. Moreover, there was no discussion of the plant load factor during 1971 to permit evaluation of potential concentrates at predicted full load operation.

12. Page F-14 Table F-3 — As previously noted, liquid releases do not include Sr-90, Cs-137, and I-129.

13. Page F-15 — It is stated that within five years all high level liquids will be converted to solids. Section F of the "Survey" should address the impact of the solidification process upon public health and the environment. For example, the more volatile fission gaseous products (Ru-106, I-129, etc.) might be released during any of the candidate solidification processes. Since NFS was operational at

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the time that 10CFR50, Appendix F was enacted, the wastes will be stored in liquid form at NFS for more than five years. This point should be clarified with an estimated schedule for converting the existing high level wastes at NFS to a solid form.

14. On page F-23 and F-24 under Gaseous releases the estimated activity to be released annually by the model plant is summarized in Table F-5. Clarification is needed as to whether there will be any significant difference between estimated releases and actual releases.

15. Page F-26 — In describing the liquid wastes from NFS, it is noted that the 10CFR20 MPC's are exceeded at the point of release. The average concentrations or the factors by which the MPC's are exceeded at point of release should be included and as previously recommended other radionuclides such as Sr-90, Cs-137, and I-129 should be included.

16. Page F-26 — The Survey states that receiving stream measurements of H-3 and Ru-100 were less than 4% of the limits in 10 CFR 20. This should be clarified as Buttermilk Creek concentrations did exceed 4%. The reference apparently refers to the maximum concentration offsite after [extended] dilution of Buttermilk Creek in Cattaraugus Creek. The statement implies there are no other isotopes released and this should be corrected. DEC's environmental monitoring program detected Ru 106 at 1% of 10 CFR 20 in one daily sample from Cattaraugus Creek and at 8.4% of 10 CFR 20 in one weekly composite sample in 1971. In May 1971 the Sr-90 in a weekly composite sample was 45% of 10 CFR 20 limits.

17. Page F-26 — The statement is made that the stream (Cattaraugus Creek) receiving Nuclear Fuel Service Liquid

waste is not a potential source of drinking water and that there is little potential for radiological effects to human beings from this liquid effluent stream. There is no basis provided in the "Survey" for this conclusion. Moreover, Cattaraugus Creek discharges to Lake Erie. There are a number of public water supplies on the New York side of Lake Erie which could be affected by discharges. Furthermore, Cattaraugus Creek should not be eliminated as a potential source of drinking water. However, on the basis of keeping exposure to radiation as low as practicable, alternate sources of comparable or better quality than Cattaraugus Creek that do not receive the liquid effluents from NFS would be preferred sources for public water supplies.

18. Page G-1 — It should be noted that Appendix F did not require NFS to convert high level liquid waste stored for five years to solid form.

19. On page G-2, the second paragraph indicates that radioactive wastes other than high level are buried in shallow trenches in the containers in which they are shipped and there is no intent to recover the wastes once they are buried. Also on page G-4, it indicates that wastes other than high level as defined in Appendix F-10 CFR-50 regardless of its source may be sent to a land burial site for disposal. The basis for this statement is not clear and does not appear to be consistent with the United States Atomic Energy Commission policy as referred to in Manual Item 0511 dated March 20, 1970 in which it is required that United States Atomic Energy Commission contractors segregate certain wastes.

20. Page G-4 — The burial of all wastes other than high level as defined by Appendix F in non-recoverable form at commercial burial sites is under review by at least two task

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forces at this time and it is anticipated that a more restrictive criteria will be developed.

21. Page G-5 — At least one site, NFS, does not have monitoring wells.

22. Page G-12 — The description of a model land burial facility does not reflect some of the operating problems. The trenches at the NFS site all have water in contact with the wastes as a result of accumulation of rainwater in the trenches.

23. Page G-16 — In discussing land use, there is a statement that there will be only a few curies in wastes other than high level for an annual fuel requirement. The resins shipped from operating nuclear power plants are apparently not included in this estimate. The solid wastes from NFS including those from the low level waste treatment plant would have a significant quantity of radioactivity that should be included in the estimated number of curies. This information should be included in the proposed appendix to the "Survey" (see Comment #1).

24. Page H-21 — The traffic aspects refer to 48 shipments on public highway and states that there should be no need for overweight permits. Any spent fuel shipment by truck will require an overweight permit and the number of shipments of spent fuel will likely be in the range of 100 truck shipments. This emphasizes the desirability of including all portions of the fuel cycle in this Survey. This information should be included in the proposed appendix to the "Survey" (see Comment #1).

25. Page S-48 — The summary of waste management makes no reference to the USAEC's practice at their oper-

ational facilities of segregating wastes with alpha contamination and prohibiting these contaminated wastes from non-retrievable shallow land burial such as used at commercial burial sites.

26. Page F-3 Table F-1 — As noted in comments on summary table, Sr-90, Cs-137, and I-129 should be included in the liquid effluents.

27. Page F-5 — In discussion of radioiodine it is not clear whether the predicted maximum dose is based on I-129 or I-131 or a combination of all radioiodines.

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UNITED STATES OF AMERICA

ATOMIC ENERGY COMMISSION

[1]

IN THE MATTER OF

URANIUM FUEL CYCLE

Docket No. RM-50-3

New Executive Office Building
Room 2010
Washington, D.C.

Wednesday, 17 January 1973

The above-entitled matter came on for prehearing, pursuant to notice at 10 a.m.

BEFORE:

M. D. PAGLIN, Esq., Chairman.
DR. JOHN C. GEYER, Member.
DR. M. J. STEINDLER, Member.

APPEARANCES:

JOHN K. RESTRICK, 175 Curtner Avenue, San Jose, California, on behalf of General Electric Company.

GORDON BURLEY, 5600 Fishers Lane, Rockville, Maryland, on behalf of the Environmental Protection Agency.

RONALD LEE, Rockville, Maryland, on behalf of Nuclear Fuel Services, Inc.

MARVIN UPTON, Isham, Lincoln & Beale, Chicago, Illinois, on behalf of Commonwealth Edison Company.

GEORGE GLEASON, New York, New York, on behalf of Atomic Industrial Forum, Inc.

[1-A]

GEORGE EDGAR, 1140 Connecticut Avenue, N.W., Washington, D.C., on behalf of Babcock & Wilcox and Nuclear Materials and Equipment Corporation.

ANTHONY Z. ROISMAN, 1712 N Street, N.W., Washington, D.C., on behalf of Consolidated National Intervenors and Union of Concerned Scientists.

PETER A. LINDLEY, P. O. Box 355, Pittsburgh, Pennsylvania, on behalf of Westinghouse Electric Corporation.

ROY NELSON, on behalf of Jersey Nuclear Company, Inc., (Exxon Nuclear Company, Inc.)

GEORGE C. FREEMAN, JR., DAVID BROLLIER, and CLAUDIA COPELAND, Hunton, Williams Gay & Gibson, 700 East Main Street, Richmond, Virginia, on behalf of Baltimore Gas and Electric Company, Boston Edison Company, Consumers Power Company, General Public Utilities Corporation, Long Island Lighting Company, New England Power Service Company, Northeast Utilities Service Company, Pacific Gas & Electric Company, Philadelphia Electric Company, Public Service Company of New Hampshire, Public Service Electric & Gas Company, San Diego Gas & Electric Company, Southern California Edison Company, Virginia Electric & Power Company, and Yankee Atomic Electric Company.

LEONARD GELLER, New York, New York, on behalf of the S. M. Stoller Corporation.

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oral presentation that would assist the Board and the Commission in understanding the issues and perhaps highlighting them? I am saying oral presentations are very necessary, but the question is does one need to make an extensive oral presentation if, in fact, it is covered?

My own personal feelings are in these matters, it is like a brief. You file a brief; you use the opportunity for oral argument, perhaps to highlight it or to raise questions [18] to permit the tribunal to ask questions and you answer them, but not to repeat the substance of the brief, more than in a mere brief outline.

MR. GLEASON: I think we would be guided by your desires that we not repeat material that would be better presented in written form.

CHAIRMAN PAGLIN: Thank you.

As I indicated, the Board considers these as requests for time and we will try to be as reasonable in meeting the requests as circumstances will permit.

Let me digress by saying this is my first proceeding. I have already made my first faux pas and I want to get it behind me. I knew there was something about the order in which I was going to call upon the participants, but my gut didn't tell me what it was. I guess in my opening the proceedings and the nervousness. The faux pas consists of having failed to call upon the Regulatory Staff to open it.

(Laughter.)

CHAIRMAN PAGLIN: Now that I am down to the first page with profound and abject apologies, and I can assure you it won't happen on February 1, I would like to call on Mr. James Murray, representing the Staff, to let us know what the Staff's position would be.

MR. MURRAY: I wonder if it would be useful, Mr. Chairman, for me to sit here? I could talk to the microphone.

[19]

CHAIRMAN PAGLIN: So long as they can all hear.

MR. MURRAY: Mr. Chairman, we plan to make our presentations in two segments. First will be by Mr. S. H. Smiley, the duty director for fuels and materials, who, incidentally, is sitting directly to my left at this moment, who will present a sort of an overall picture of the environmental impact of the fuel cycle as we see it, based on the survey, the environmental survey of the fuel cycle, this yellow book prominently displayed before you gentlemen. Also I believe I tried to send it to everyone who has expressed an interest in these proceedings. We also tried to send, as we became aware of them, to those same persons, copies of all the references that aren't copyrighted, contained in that yellow document.

In addition, we have tried to send out some references specifically focused on the waste management area that Dr. Pitman, who will present the second portion of our presentation, will deal exclusively with.

We expect, Mr. Chairman, that these two statements together can be completed in approximately three-fourths of an hour. These will be the two primary lead witnesses we have with us. We also plan to have some 10 or 12 additional technical people on hand to respond to questions as they may arise.

I believe that completes what I was going to say.

[20]

CHAIRMAN PAGLIN: Thank you, Mr. Murray. It reminds you—your last statement reminds me of a question that was raised by one of the participants in an earlier letter prior to the supplemental notice raising the question

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as to whether or not the participants will be permitted to bring with them other technical personnel who would be available as a resource for the Board or participants. I would think, yes, of course, we would welcome that because if I may be somewhat colloquial, the name of the game is to compile a record as complete and as meaningful as possible, so as to permit the Commission to reach an informed decision in the matter; and the more cooperation and the more information we get in that regard, I think the better the proceeding will turn out to be.

All right. Now, do I have your forgiveness, Mr. Murray?

MR. MURRAY: My wholehearted forgiveness.

(Laughter.)

CHAIRMAN PAGLIN: Thank you, sir.

I now turn to page 2. I have listed on page 2, No. 14, Babcock and Wilcox, Washington.

MR. EDGAR: I am George Edgar of the Washington firm. I represent both Babcock and Wilcox, and NMEC, Nuclear Materials and Equipment Corporation, in these proceedings. We have reviewed our respective positions, and upon further consideration, believe that it would be in the [21] interests of expedition to consolidate those positions. We contemplate making a written statement on behalf of Babcock and Wilcox and its wholly-owned subsidiary, NMEC, jointly.

In addition, we do not contemplate making an oral presentation at this time. We, therefore, believe that the NMEC petition can be considered withdrawn and Babcock and Wilcox will appear as one entity.

CHAIRMAN PAGLIN: Thank you, Mr. Edgar.

Next is Sport Fishing Institute, and they have filed a statement and there is no indication they intend to appear for an oral presentation. I take it from Mr. Edgar's remarks that this takes care of Nuclear Materials and Equipment Corporation?

MR. EDGAR: That's correct.

CHAIRMAN PAGLIN: Thank you.

Next is the Consolidated National Intervenors and the Union of Concerned Scientists of Washington. Mr. Roisman.

MR. ROISMAN: My name is Anthony Roisman. I represent those two groups which, as we indicated in our filing, will be making a single presentation. I think that for us, perhaps different than the other participants who have spoken so far today, we see the hearing in a somewhat different context and because of that and since it reflects on the question of oral presentation time, I would, if I could, **[22]** take a moment to explain that.

As you may know, this is the first time the Atomic Energy Commission has brought into the open for public discussion, the question of—particularly of nuclear waste reprocessing and waste disposal from an environmental standpoint. This is a time that we feel is important to get some things before the public that have not previously been there. We are not wholly satisfied with the survey as a substantive document and note that other participants have similar problems with it. We trust that the public, represented through the press and individuals, will come to the hearings and will orally hear much of what has not previously been heard. We think the oral presentations are extremely important because we know that there is a certain unwillingness to track down in the public docu-

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I have, I hope, sufficient copies of those lists and, Ms. Janinek, would you be good enough to have them distributed to the people here?

It will give you an idea of who has filed and who is to be contacted in the event you need information from them.

That list is as up to date as we have been able to get it, as of yesterday afternoon. I am presuming that January 15th, having passed that, that being the date the commission specified, everyone is in.

I will refer, later, to the two requests for extensions of time.

What I would propose to do now, is to call upon those — the participants present today, and ask them to note their appearances, and on whose behalf they are appearing. I trust the group will bear with us, as we go down the line. It is for the record we are making.

I would like, also, for the participants when they rise, and give their names and on whose behalf they are appearing, to let us know whether or not they wish to make an [8] oral presentation on February 1, in addition to the statements and, if so, what areas will be dealt with, and how much time, approximately, they will require.

In this connection, I would like to make specific reference to the fact that the Commission's notice, referring as it did, to the privilege or opportunity for oral presentations, sais specifically, that depending upon the time available, the participants may be permitted to make brief oral statements, either in addtion to, or in lieu of written submissions.

I ask you to keep that in mind in giving us your statements. We do not have an unlimited amount of time and again, keeping in mind the nature of the proceeding, we want to get an estimate of how much time you think you

will need, and on the basis of these estimates, the Board will make out lists of time.

I would hope, further, that in the interests of expediting this portion of theproceeding, we would like to encourage the participants to make joint presentations if their positions permit it, and concurrences in already expressed positions, supplemented, if they wish, by the addition of written submissions.

Our feeling is the opportunity given by the Commission to these supplemental written submissions is an opportunity which can be used in lieu of a lot of oral argument, [9] because you will have the opportunity then to see the record, to see the submissions, and you can make your response, rebuttal, however you will, in the form of these written submissions to be submitted 30-days after the close of the oral portion.

When we organized the schedule, we would hope, in the light of what you tell us today, to organize the presentations so that as meaningful and as logical a record can be made for the Commission's use in this proceeding.

Now, what I would like to do is call on the participants according to the list, and ask them to give us the information that I have indicated.

Remind me there are two other parties because of conflicts in other Commission proceedings unable to be here today, but they have indicated they would like to have time for oral presentations.

There is no particular order in which I am calling the persons, now. They happen to be the order in which the materials were filed with the Secretary, and in which the Secretary served on the participants.

There is no other criterion that I have used in making up this list, nothing to the contrary should be inferred.

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Like, starting with General Electric. Their representative, I have here?

MR. RESTRICK: John Restrick, attorney for General [10] Electric Company.

We would plan to primarily file a written statement. We would like to have a brief oral statement, I would expect not more than fifteen to thirty minutes.

Exchanger areas.

We would, in the written statement, cover which alternatives we favor primarily and some comments on the environmental survey and the areas in which we participated which are primarily fabrication, and reprocessing, and possibly some transportation aspects.

CHAIRMAN PAGLIN: Thank you, very much.

If the reporter fails to get the spelling, please ask them.

Next, I have is Duquesne Light Company.

Are they here today?

(No response.)

I see some notes I made.

The next three, according to my notes from the information we got, from the parties will be submitting only written statements to my understanding.

That would be the next, Duquesne Light, Mississippi Power and Light Company, Gulf General Atomic Company.

If my information is correct, they will probably only be submitting written statement.

Next, I have on the list is Environmental Protection Agency.

[11]

MR. BURLEY: Gordon Burley. Office of Radiation programs, Environmental Protection Agency.

We intend to file a written statement probably supplemented by an oral summary and possibly some additions. Our representative at the hearing will be Mr. W. D. Rowe, the Deputy Assistant Administrator for Radiation Programs, and the subject will be, primarily, the alternative which we favor and the problems with the genral approach as presented in the Federal REgister notice.

CHAIRMAN PAGLIN: Thank you, Mr. Burley.

Next on the list, my notes indicate University of California, Professor Ruby has filed a statement. He will not be making an oral presentation.

Next, I have Nuclear Fuel Services, Rockville.

MR. LEE: Ronald Lee, Nuclear Fuel Services.

We will be participating in the preparation of the atomic industrial forms comments, and we will not submit either a written or an oral presentation, independently.

CHAIRMAN PAGLIN: Thank you, sir.

Minnesota Pollution Control Agency.

That is one of the notes that I have. Mr. Ken Dzugan has a conflict. He is in another AEC case. He has indicated he will be present at the February 1st, session, and has asked for about thirty minutes. I did not get from him the areas of his presentation. We will have to get that [12] supplement.

Sierra Club, Legal Defense Fund, Inc.

(No response.)

Again, if I recall, yes, Mr. Lash and Mr. Hoffman, John D. Hoffman. This was apparently — they have written to

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the Secretary indicating, and I spoke to them on the phone, there was a delay in the mails, and they did not get the materials in time.

They have requested an extension of time, until January 25th to submit their written submission. It is yet undetermined as to whether or not they will want to appear.

Considering the circumstances, the Board is of a mind to grant this extension and unless there is serious objection from any other participants, we would advise them that they do have that extension, which they requested.

Do I hear any objection?

(No response.)

All right.

We will advise them they have an extension until January 25th for their comments.

Next, is Commonwealth Edison Company here?

MR. UPTON: I am Marvin Upton. I am representing Commonwealth Edison Company, here, today. Commonwealth Edison is one of eight organizations on behalf of which I filed written comments on Monday of this week. If the Chairman would [13] like me to, I may have others, if I can remember them.

Alabama Power Company, Consolidated Edison Company of New York, Inc., Hydro Mohawk Power Corporation, Power Authorities, State of New York; Omaha Public Power District; Rochester Gas and Electric Company; Georgia Power Company.

I might also say, Mr. Chairman, that I am also representing today, the Edison Electric Institute which will appear later, on your list. It is probably, most probably, that the

Edison Electric Institute will not take any position with respect to the various alternatives offered by the Commission.

However, the Institute has a continuing interest in the procedures that are to be followed in the course of this proceeding. I shall be representing them in that connection and in that connection, only.

CHAIRMAN PAGLIN: And you will not be making an oral presentation?

MR. UPTON: We don't expect to make an oral presentation.

Mr. Miller, who—of Isham, Lincoln & Beale of Commonwealth Edison, whos name you have listed there, did file a notice of intention to participate before the deadline on January 1, and reserved his right to participate fully.

I don't anticipate that Commonwealth Edison, or any of the other organizations, I have listed, will be submitting [14] oral statements.

Certainly, if any of them do, it will have to be reasonable notice to all the other parties involved if they plan to do so before the hearing commences.

CHAIRMAN PAGLIN: Fine.

MR. UPTON: However, I am sure that all the eight organizations I name, we do plan to file supplemental comments after the hearing record is concluded.

CHAIRMAN PAGLIN: Fine.

Thank you very much, Mr. Upton.

Mr. Gadler? Steve J. Gadler also informed us that he has a conflict. I think he is in the same proceeding as Mr. Dzugan. He will not be able to attend today.

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He will want to make an oral presentation and will want approximately 30 minutes. He is an individual citizen, who has participated in a number of these proceedings in the Minnesota area. Again, I don't know the specific areas of his presentation.

Next on our list is Teknekron, Inc., of Washington.

Is their representative present?

(No response.)

All right. I have, next listed, the Atomic Industrial Forum, Inc., and that was Mr. Lee—I mean—who is the gentleman who appeared for Nuclear Fuel Services?

MR. LEE: Ronald Lee. I believe the Atomic [15] Industrial Forum is represented separately.

CHAIRMAN PAGLIN: I beg your pardon.

Sir, your name?

MR. GLEASON: I am George Gleason, counsel for the Atomic Industrial Forum. We would like an opportunity to make an oral statement. Our oral statement will be directed both to the substance of the environmental survey.

We have, through the forum, which represents many of the companies that are engaged in fuel cycle activities, we have put together a group which is in the process of reviewing the environmental survey and developing detailed comments on it.

I suspect that our comments with respect to the survey may be more detailed in nature than most of the other organizations that will be filing comments.

For that reason, and here, I would like to seek the guidance of the Board, I think that it might be useful in the course of our oral statement to give a fairly detailed

view of our appraisal of the environmental survey, since it may not otherwise be brought up in the oral presentations.

So, much of our oral statement would be directed to the environmental survey. We would also like to discuss the two alternative rules that are before the Board. We will not, I think, take a position in favor of Alternative One, or Two, because, as the Board is probably aware, there are [16] substantial differences of opinion with respect to the precise wording of those rules, and since we represent many organizations, we feel that we can not take a position in favor of one or two, but we do have some views we would like to express.

I would think that we could make our oral presentation in about 90 minutes.

[17]

CHAIRMAN PABLIN: May I use this opportunity, Mr. Gleason, to comment—and I welcome the comments of my—all the members of the Board. I would like to make reference back again to the Commission's notice. It seems to me that what should be kept central in the minds of the participants is not only the nature of the proceeding, but also whether or not the questions you want to raise, the problems you want to highlight cannot be covered adequately in your written statement; and here again, permit me, perhaps impertinently, to say I've alwaos governed myself—or at least I would like to have this governed by why can't it be covered in the written statement, number one; number two, what is there in the oral presentation that will add a measure or a dimension that is not covered in the written presentation?

We do not mean to be inflexible about it, I wish you to know that. But by the same token, I asked the participants to think of it in those terms. That is there in your

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[2]

PROCEEDINGS

CHAIRMAN PAGLIN: Good morning, ladies and gentlemen. Can you — are these mikes working? Can you hear me?

I am Max Paglin and to my right is Dr. Steindler of the Argonne National Labs; and to my left is Dr. Geyer, from Johns Hopkins. We constitute the Board which the Atomic Energy Commission has appointed for this rulemaking hearing in the nuclear fuel cycle.

The purpose of this procedure planning session is as has been authorized by the Commission's supplemental notice in December of '72 to assist the Commission in carrying out one of the objectives of this legislative type hearing and that is to conduct it as expeditiously as possible.

Our objective this morning will be of a procedural nature. We would like, with the cooperation of those people and representatives present, to note the appearances, to attempt to set up dates and times to be allowed for oral presentations to the extent the parties wish to make them on February 1st, and to allow those participants who file notices and requests to participate in the February 1st hearing.

What we also intend to do this morning is to discuss the procedures which will govern the February 1st hearing.

Now the supplemental notice of December 27, and I assume that all of you have gotten copies, will actually be the document which will govern the procedures albeit the [3] Commission indicated there is to be flexibility, that there is to be informality, and that it is to be in the nature of a legislative type hearing. I will supplement it by saying the kind of hearing a contressional committee conducts when it is on a fact-finding inquiry.

The participants have been served, as I understand, with the supplemental notice by the Secretary.

Now there were in some of the preliminary letters sent to the Secretary a number of questions as to procedure, and I believe that probably most of them were answered by the supplementary notice. In fact, I believe that there was a crossing in the mail. I trust that some of the questions that were asked, for example as to whether or not the witnesses would be permitted to be accompanied by counsel, whether or not cross-examination would be allowed, et cetera, these were answered in great part by the supplemental notice to the extent they weren't, it is the purpose of this session to try to set up some effective and reasonable procedures for the conduct of that proceeding.

Now the proceedings will be recorded and a transcript will be made. It is contemplated that the Regulatory Staff will open the proceedings with a prepared statement and then supplemented by oral presentations and I understand that when we call on the Regulatory Staff — but my understanding is now there will be two witnesses for the [4] Regulatory Staff. We are also — it's also been indicated that to the extent feasible, these statements will be distributed in advance. I would hope enough time will be available so that they can be mailed out to the participants and they will have them sometime before the February 1st session.

Now as far as those participants who desire to present additional written submissions, that is in addition to those that have been required by the Commission's notice to be filed by January 15th, the Board would like to have those written statements filed with it at least 48 hours in advance of the February 1st hearing so that the Board may have an opportunity to review them for purposes of questioning.

As you know, and I refer to it in some more detail later on, questioning will be conducted only by the Board members. Therefore, it seems to us to be the most useful pro-

cedure to get these written — additional written submissions to us some 48 hours in advance of the February 1st hearing.

We would also like for sufficient copies to be brought to the opening of the hearing on February 1st for distribution to the other participants at the hearing.

Finally, we have been requested by the Secretary's office to direct that 10 extra copies, in addition to those I have mentioned, be furnished and filed with the Secretary for the necessary docketed files.

[5]

Next, those who desire to make oral presentations, either as by way of summary of the written presentations or by way of comment on the other written submissions, should, if possible, file with the Board in advance, and when I say in advance, I mean reasonably, depending on the circumstances, a brief outline of the major areas which you propose to cover. Again, keep in mind it is the view of the Board that this will help expedite this proceeding, it will assist the Board in, shall I say getting a handle on what is being brought into the record.

Also, as you know, as the supplemental notice indicates, the participants will have the opportunity to file supplementary written statements as they may deem necessary and appropriate in light of the hearing record that will be made on those days. Those statements can be filed during the period of 30 days after the oral portion of the hearing has been completed. I mention the fact that the Commission has indicated, with respect to the procedures which will be followed in this rulemaking informal hearing, of a legislative type, that no cross-examination will be permitted by the participants of witnesses appearing, no discovery was mentioned; however, the participants appearing will be subject to questioning by the members of the Board.

[6]

Now there were some questions raised in the correspondence from some of the participants whether or not the participants could propound questions to those appearing as witnesses, through the Board.

It is the feeling of the Board that in keeping with the intent of the supplemental notice of the Commission, as to the nature of this proceeding, that it would not be appropriate for the Board to accept questions from the participants to be propounded to other participants.

It is our feeling that, in keeping with the intended nature of this proceeding to the extent that participants wish to raise questions regarding the positions taken by others on the survey or the proposals as to the amended rules, that they may do so in their oral presentations to the extent they have had advance notice of these positions, for example, the statements that have already been filed; or they may use the opportunity which has been given to them by the Commission, of the supplemental written submissions to highlight and point up the problems, and the questions which they feel are raised in the written and oral presentations of the other participants.

This would obviously be for the benefit of the Board, and for the Commission to whom, as you know, under the notice, this entire record will be certified in accordance with the procedural regulations specified by the Commission.

Now then, this is by way of preliminary as to the [7] proceedings which we will follow in the February Board hearings.

Now, what I have done is, I have taken the liberty of preparing a rather informal list of the participants who have already filed, indicating statements and/or oral — opportunity to make oral presentations.

ment room of the Atomic Energy Commission and read bulky materials such as this or what we will be submitting in writing after the conclusion of the hearing.

We think that there is a useful purpose in getting a number of things out in the open at the hearing. We, therefore, expect to cover all aspects of the fuel cycle, as well as the legal questions raised in the course of our presentations; not in detail, that is individual figures and statistics. Those will come up in a written comment; but rather to do an adequate job of highlighting the problems. We **[23]** think that is going to take something in the nature of 180 minutes. We will be covering seven areas and I will go briefly over those now in addition to the legal questions. **[24]**

One is the uranium mining operations area. We will be discussing miner's exposure to radon and solid mine waste disposal, both disposal piles and radium contamination of water as well as the use of tailings in construction.

The fuel enrichment area will be concerned with toxiological problems, effects on workers, toxic waste.

Transportation of weapons grade material will be concerned primarjly with the diversion for terrorist purposes.

In the fuel utilization area we will be discussing the radiological effects of planned releases of activity, gaseous liquid and food chains, and the radiological effects of the massive accident probabilities, including sabotage and possible consequences.

In the transportation of radioactive wastes we will be concerned with accidents, chances and mechanisms, and the consequences.

In the area of fuel reprocessing plants, we will deal with planned and unplanned releases, local and global, quanties, and consequences.

We will talk about technical improvement which could be made in the area and recommendations in the area.

Finally in the waste storage discussion we will be dealing with the history of unplanned releases, methods of disposal: salt mines, ocean dumping, Hanford solar, [25] the future ethical and moral problems, and required government stability, recommendations, and alternatives.
[26]

In all of the seven areas we will be following the general outline. In an introductory comment we will talk of the scope of the subject, the review of the approach, the summary of results, conclusions.

We will have a historical segment which will discuss appropriate past weaknesses and thereby display lessons which can be learned from the past.

The body of the discussion will deal with the methods that are used to analyze the environmental effects, input data, results, and conclusions.

Finally, we will make recommendations in each one of the areas.

Needless to say this presented orally will be in a summary form of what will eventually be presented in written form.

Our written comments will be filed within the 30-day post hearing comment period in order to take advantage of the comments made by other parties and to incorporate them into the final report.

What we hope to produce in that period of time and are working on now is in effect, another environmental survey of the nuclear fuel cycle that more thoroughly discusses this serious environmental consequence associated with the fuel cycle.

In addition, we will be making a legal presentation, [27] that is, what are the legal consequences associated with the choices that the Commission has made and whether those represent the realistic alternative legal choices or are there other possible legal positions which the Commission could or should be taking.

In the course of that discussion, which will be very short, I will be making the presentation. During the remaining part the presentation will be made by technical people whom I tentatively identified when I filed our Notice of Intent to participate. But as I indicated there, that may well change partly depending upon what we hope will be resolved today. That is the time when our people will be on, that is the date certain so that we can arrange their traveling schedules.

Many of them are teaching at universities and have potential conflicts that cannot be resolved.

We will take whatever date the Board gives us at this hearing or subsequently and simply arrange our witnesses based upon the available time.

We do not think that the 180 minutes will be in any way repetitive of the detail that will appear in the written statements, but we do think it will be extremely important to prevent any misunderstanding of our position or any misunderstanding on the subject matter of the environmental effects of the nuclear fuel cycle.

[28]

We realize that it is somewhat longer than what the other parties have so far requested, but in the same vein as with the atomic industrial form, we indicate the conglomeration of the intervenors across the country and while there are individuals who are participants in the National Intervenors, who will be appearing here separately such as Sierra Club and the — Mr. Gadler, nonetheless, their

presentations will by comparison be quite small. We are trying to do the overall picture.

Given that, the representatives of the vendors of the industry and of the Commission, to some extent are on the opposite side and don't think that the request for 160 minutes is particularly unreasonable to get a full presentation of our needs.

Finally, we are under the impression Mr. Smiley advised me of —

CHAIRMAN PAGLIN: Beg pardon?

MR. ROISMAN: Mr. Smiley advised me, I spoke with him on the phone, the hearing had been reserved for seven hearing days — two the first week and five the second.

Based upon that, it would seem for the number of participants we do have enough time even if we stay within the outer bounds. Maybe that was the Commission's conservative assumption regarding the length of the hearing and they perhaps — we represent the unanticipated event.
[29]

In any case, we feel that the time we requested will be essential to make a meaningful participation and hope that the Board will give it serious consideration.

Thank you.

CHAIRMAN PAGLIN: Thank you, Mr. Roisman.

I might comment by way of a footnote that as far as the Board members are concerned, we had not attempted to make an estimate of the length of the hearing, awaiting the very purpose of this planning session so we could get some idea of the parameters of the proceeding.

I have no present idea how long we will need. I am following the mandate of the Commission that this should be an expeditious hearing albeit an informal one.

I thank you for your statement, Mr. Roisman.

We will certainly give it very serious consideration.

Do the Board members have any questions of Mr. Roisman at this stage, because it is a little unusual, if the other participants will permit me, because of the rather unique nature of Mr. Roisman's comments now as contrasted with the others? At this stage, the Board members would like to ask questions, or would you prefer to go through the list and come back up?

DR. GEYER: I would like to suggest to Mr. Roisman that it might be helpful if he would give us a list [30] of the people he is representing.

We had that in other hearings, but I think it would be nice to have it here.

MR. ROISMAN: You mean the list of participants in the National Intervenors?

DR. GEYER: Yes.

MR. ROISMAN: I will be glad to provide that to the Board and we will do it in a number of days.

DR. GEYER: Thank you.

CHAIRMAN PAGLIN: May we now continue?

Next on the list is Westinghouse Electric Corporation.

MR. LINDLEY: I am Peter Lindley of Westinghouse.

Westinghouse would like the opportunity to enter a brief oral statement, probably 15 to 30 minutes in length.

This staement will concentrate in the main on the areas of the fuel cycling which we are interested in, but we would like to offer comments upon the alternatives before the Board.

Our presentation — we — will be given by Mr. W. J. Dollard, General Manager of the Nuclear Fuel Division. But we would like the opportunity, if necessary, because of his schedule to put — to have the statement made by some other designated person.

CHAIRMAN PAGLIN: That would be acceptable. Thank you, sir.

[31]

Next on the list is the Edison Electric Institute, but my recollection is that Mr. Upton indicated you would cover that? You would cover for them?

MR. UPTON: Yes. I have already covered the extent of the participation.

CHAIRMAN PAGLIN: Thank you.

Next is — with the new name being changed throughout the country, Exxon Nuclear Company. Did you bring the tiger?

MR. NELSON: I am Roy Nelson. We will file a written statement with possible oral statement that will take five minutes.

CHAIRMAN PAGLIN: You said possible oral statement. You don't know at this stage?

MR. NELSON: I don't know at this stage.

CHAIRMAN PAGLIN: Is there some way the Board can know whether or not you want oral time allocated?

MR. NELSON: We will let you know in a few days.

CHAIRMAN PAGLIN: Fine. Thank you very much. I have the electric utility group by Mr. Freeman.

MR. FREEMAN: I am George C. Freeman, Jr., with the law firm of Hunton, Williams, Gay & Gibson, Richmond, Virginia. I am appearing for the following electric utilities.

and also the counsel listed in our notice of appearance which I will not repeat at this time:

[32]

Baltimore Gas & Electric Company. I might indicate, though, Mr. Robert Buchanan of the legal department of Baltimore Gas & Electric Company is with us today.

Boston Edison Company.

Consumers Power Company.

General Public Utilities Corporation.

Long Island Lighting Company.

New England Electric System.

Northeast Utilities Company —

CHAIRMAN PAGLIN: Excuse me. May I interrupt you?

MR. FREEMAN: Yes, sir.

CHAIRMAN PAGLIN: Did we have the listing wrong? You call it New England — we have New England Power Service Company. Is that different from the one you just read?

MR. FREEMAN: Yes, sir. It should be listed as New England Electric System.

Northeast Utilities Company.

Pacific Gas & Electric Company.

Philadelphia Electric Company.

I might indicate that Public Service Company of New Hampshire has indicated that they will not participate in this rulemaking, and therefore they ask their name be deleted.

But continuing the utilities that we are here representing — Public Service Electric & Gas Company.
[33]

San Diego Gas & Electric Company.

Southern California Edison Company.

Virginia Electric & Power Company.

Yankee Atomic Electric Company.

On behalf of these companies, we have already submitted written comments for the record. We would like to reserve, if possible, 30 minutes of time. We would hope that we would be permitted to come before the last of the persons commenting for the following reasons:

First, we would not repeat in any oral statement the details of our written comments. We would, however, like to be available to briefly summarize our preference for alternative two and to answer any questions the Board might have of these utilities with regard to that preference.

Second, we are concerned, vitally concerned, with the interface between this rulemaking and the proposed rule and individual licensing cases.

The issue of the relationship of this proceeding and the survey and individual licensing cases has been raised in several pending licensing cases for members of our group.

Finally, we would like to be able to perhaps respond and comment on crucial technical questions which might particularly affect the utility industry as they may be raised in the comments of others preceding us in the [34] proceedings. We would estimate at a maximum 30 minutes that would be required for that purpose, and if, indeed, when the time came we felt it would not be in the public interest or our clients' interest or to the Board's interest to take that time, we would, of course, not do so.

CHAIRMAN PAGLIN: Thank you, Mr. Freeman.

The S. M. Stoller Corporation? I recall now Mr. Stoller called our office and indicated that he would not have someone present — Dr. Leonard Geller?

DR. GELLER: I am here.

CHAIRMAN PAGLIN: May I tell Dr. Geller what's involved?

We are calling the list of participants and asking them to indicate whether they will want to make oral presentation in addition to the written submission; if so, what areas will be covered and how much time they will need.

Can you — catch your breath — say something?

DR. GELLER: I would say five to 10 minutes.

CHAIRMAN PAGLIN: What areas do you think you will cover?

DR. GELLER: I don't know yet.

CHAIRMAN PAGLIN: Thank you very much.

For your benefit, sir, there is a transcript being made of this planning session so that you can find out what went on before you arrived.

[35]

The New York State Atomic Energy Council?

Anyone here on their behalf?

(No response.)

Consolidated Edison has indicated they will file a statement and not requested —

MR. UPTON: Mr. Chairman, Consolidated Edison is one of the group on behalf of which I filed a statement.

CHAIRMAN PAGLIN: I hope you have a better chance at keeping track of your clients than I am.

(Laughter.)

Thank you, sir.

New York Public Service Commission?

(No response.)

The Natural Resources Defense Council, is that — that's the group I told you about that asked for the extension of time.

Gulf United Nuclear Fuels has indicated they will only file a statement.

And Franklin L. Gage has filed a statement and I don't know whether or not he's indicated he wishes to appear. I won't take up the time of the group. We will look into the question of whether or not his letter indicated he will need time. If he does, we will schedule him accordingly.

Now are there any questions from the participants up to this point as to the procedures which will be followed? **[36]**

MR. FREEMAN: Mr. Chairman?

CHAIRMAN PAGLIN: Yes, Mr. Freeman?

MR. FREEMAN: I take it under the procedures which will be followed here that there will not be the usual service of various statements, motions, and papers, on counsel for the various participants; that that is not in the overall format. I would like to ask an — ask as a matter of courtesy among counsel that are here that we agree on such an understanding, and I, for my part, would be delighted to furnish copies of any materials which we filed on behalf of the 14 utilities which we are representing, and would

appreciate copies being sent to us. I think it — as far as the Staff were concerned, they intend to do that.

MR. MURRAY: Yes, that's right.

MR. FREEMAN: I think it would be very helpful for all of us, though, if we could, because to the extent we would make oral statements, having material in advance would be of assistance and save the time of everyone.

CHAIRMAN PAGLIN: Does the Staff have a view on that?

MR. MURRAY: Yes, Mr. Chairman. We fully intend, as Mr. Freeman anticipates, to make available everything we have in writing in this whole area to every participant who indicates an interest in receiving this material. We are assuming anyone who is on this list that we have before us [37] has indicated such an interest. We think it is a good idea. We don't wish to impose that view on anybody. It is not formally within the prescribed format for the proceeding, but we certainly will follow it ourselves, and we are glad to hear that the utilities will be following it.

CHAIRMAN PAGLIN: You will do so in advance?

MR. MURRAY: Oh, yes. As soon as they are available. [38]

DR. GEYER: Will you provide a list of the people whom you are sending the material to, the other participants?

MR. MURRAY: Dr. Geyer, I am using the Chairman's list.

DR. GEYER: Mr. Murray indicates he will be sending it to everybody on this list.

MR. UPTON: Well, Mr. Chairman, the Chairman's list has to be revised in part.

CHAIRMAN PAGLIN: Yes, we are going to take the transcript and revise the list.

MR. UPTON: I can't imagine why all the lawyers involved — I hope the lawyers won't assume too much of a role in this proceeding. I feel this is very much like — it is a legislative type hearing and I think there's a difference in my role as a lawyer and — in a legislative type hearing when I accompany a client who is going to testify before a congressional committee and my role as a lawyer when I am handling a licensing proceeding or a court case.

The two roles of course are very different. In the congressional committee situation, the lawyer's role willingly or unwillingly is somewhat more muted, and that's somewhat the way I see the lawyer's role in this proceeding.

Certainly we are delighted to send copies of anything that we file either on behalf of the Edison Electric Institute or the eight organizations that I named to everyone else who [39] appears on this list.

CHAIRMAN PAGLIN: Thank you.

MR. ROISMAN: I am all in favor of Mr. Freeman's suggestion but I wonder if the staff would make available a list of the addresses on it so that we could make the services to the appropriate people and also where there are multiple people listed — for instance I notice here that individuals are listed who are with the individual companies or concerns and are not in Washington, but they are today represented by counsel from Washington.

If service is preferred on one or the other, maybe they could indicate an address to which those documents could be served.

CHAIRMAN PAGLIN: I think that's a useful suggestion.

Mr. Murray, would it be possible for us to get together an exact and accurate list with the names of people and addresses to whom they should be sent? I think it would be useful to us as well.

MR. MURRAY: I am sure we could do that, Mr. Chairman. When I said I am using the Chairman's list, I perhaps was aware of the fact that the Chairman, I believe you indicated —

CHAIRMAN PAGLIN: Is an informal list.

MR. MURRAY: — had developed it based on the [40] filings that the AEC secretariat office had, and of course these filings have addresses on them.

I think they were left off here because they weren't germane for this purpose.

CHAIRMAN PAGLIN: Also made up from some signatures that were not legible by the way.

(Laughter.)

I think perhaps, Mr. Murray, it would be useful once we make up such a list to distribute it to the participants.

MR. MURRAY: We will do that.

CHAIRMAN PAGLIN: Thank you.

MR. GLEASON: In response to your statement before, about the oral statement, I should point out that the forum does intend to file extensive written comments on this survey. However, we did not file them by January 15th as was set out in the written notice and it is doubtful that we will file them by February 1st and the reason for that is the scope of our review.

We simply could not be concluded within that time frame so that it may be that when we make our oral statement, we

will still not have written our extended written comment; they will not have been submitted to you.

We would attempt not to repeat or to duplicate things which would be more appropriate in written comments. [41] The fact is you probably will not have our written comments by that time and that may present somewhat of a difficulty in the Board understanding what our position is; and for that reason, it may require a little bit more time to explain it than if we had had the time to file the written statements and the Board had had the opportunity to read it ahead of time.

I regret that is the situation. It is not as a result of intentional procrastination on our part. It is the result of the extensive review that we are subjecting the environmental survey to.

CHAIRMAN PAGLIN: Mr. Gleason, may I make this request of my fellow Board members? Would it be possible for you — I understand what you are telling us — would it be possible for you to make some efforts to be of assistance to the Board in this advance preparation because again the only questioning will be by the Board.

Mr. Roisman, in making his statement this morning, indicated with some specificity the areas that would be dealt with in their presentation. Would it be possible for you to do that? Do the Board members think that would be useful?

(Board conference.)

DR. GEYER: I think so.

CHAIRMAN PAGLIN: The Board seems to think that would be useful. Would it be possible for you to give us that assistance?

[42]

MR. GLEASON: Mr. Chairman, I am not prepared to do that today.

CHAIRMAN PAGLIN: Not today. I am saying before February 1st.

MR. GLEASON: Before February 1st I will. I can give you a general outline right now which I attempted to do before. We will concentrate in our statement on an analysis of the substance of the environmental survey. We think that there are areas that we would like to touch on with respect to the accuracy of some of the material, with respect to the scope of the document, with respect to some of the methodological approaches, so that we think that the evaluation of the survey will be in some depth.

That would constitute the bulk of our presentation. We would like to address ourselves also to the alternative rules, but that will be done in a more general fashion.

I believe Mr. Roisman indicated that their written comments would not be submitted until some time after their oral presentation and within the 30-day period thereafter.

We would intend to file ours as soon as possible, perhaps prior to February 1st if it is feasible so that you will have the benefit of the comments as soon as possible.

Nevertheless, I think we find ourselves somewhat in the same situation with respect to being able to make an oral [43] statement which will be helpful to the Board.

CHAIRMAN PAGLIN: Dr. Steindler?

DR. STEINDLER: I wonder if I might address myself to that comment and to the one Mr. Roisman made

and also one of the gentlemen I think from Westinghouse indicated that the statement may be made by an alternate.

One of the things we are interested in is being able to examine the statements presumably on the basis of technical detail, and the alternate in particular; and I can appreciate the problem he might well have, and the principal speakers in general, I trust will be capable of fielding questions on the substance of their presentation in such a way as to allow us to examine those areas in which there is either serious disagreement or challenge or some such so that we don't end up with unchallengeable or unexplainable statements that kind of sit in the record and that we can't really use; the intent being here obviously to provide for as much information for the Commission as we can possibly get.

In summary, then, what I am looking for is those people who present technical discussions, either a critique of the environmental statement as issued or a supplemental statement that deals with that topic should be prepared, it seems to me, to be technically competent in the area—at least to the point of being able to answer questions.

[44]

The other comment I would like to make is that in all instances it seems to me appropriate that the presentations, particularly the oral ones, should focus as closely as possible on the content of the Federal Register notice and continue to focus on the questions that are really before the House; and if we can continue to bring back all of the discussion to the main central issues, then I think we can provide for the Commission a useful transcript they can use in their subsequent deliberations.

[45]

CHAIRMAN PAGLIN: Thank you, Dr. Steindler.

Did you have any comment? The gentleman there?

MR. RESTRICK: It appears to us it may be difficult for the Board to file—to ask questions where the people are filing written statements after the Board is over. Is it intended by the Board they would file written questions with people on the supplemental statements et cetera? Or are they going to go in as filed?

CHAIRMAN PAGLIN: We have not addressed that question specifically. I know it is certainly not my present intention to keep the record open in the matter. I think it would depend upon how the record develops. I regret that I can't give you a specific answer right now.

MR. RESTRICK: It appears two major groups will not be filing detailed comments until after the hearing.

CHAIRMAN PAGLIN: That is true and it does present some difficulty. It may be that a further session may have to be held. I just don't know at this stage.

How do my brethren feel about it?

DR. GEYER: Well, it seems to me that if we could have something from the Atomic Industrial Forum prior to their oral comments, it might help us in discussing the problems they are having.

MR. GLEASON: Dr. Geyer, we will submit as much as we can to the Board prior to the commencement of the hearing [46] and if that is no more than a general outline of what we will cover, we will at least do that. We will make every effort to give you the benefit of our thinking prior to our oral statement.

DR. STEINDLER: The present apparent lack of open-end time for submission of statements, I think, makes it even more important that the written comments are en-

tirely self-explanatory and reasonably carefully edited so as to stand on their own feet. I think if that is done, as the Chairman pointed out, the record itself may, in fact, be sufficient as it is submitted.

MR. UPTON: Mr. Chairman, I am still not entirely clear about what is going to come first in connection with these statements and comments and I would just like to suggest to the Board the way it sort of runs in my mind and see if I am right or if the Board has some other idea in mind and so forth. It seems to me that, again I keep trying to think in the context of a Congressional committee hearing because that is the way I try to think in this kind of proceeding. Ordinarily when someone appears at a Congressional committee hearing they have to submit in writing the testimony they are going to give before they appear at the committee hearings.

Sometimes they read the testimony which is usually pretty much a waste of time, I can assure you. And at other times they are allowed to summarize orally various aspects of the [47] testimony and point out other things that they think should be pointed out that didn't appear in the testimony.

Now, I don't see why we can't all be expected — and maybe I am taking this too lightly because at the moment I don't expect to make any oral presentation at the hearing, but I don't see why we can't all follow that procedure here by submitting what I would call our position in chief in writing before the hearing begins and then summarizing or clarifying or highlighting that written position while the hearing is being conducted, and then not trying to anticipate at that point what our response is going to be to what the position of all the other parties is, but trying to make those

responses after the hearing in the comments which everyone is permitted to file, written comments, after the hearing record is concluded.

What I am afraid of is if we don't watch out we are going to wind up with a situation where everyone is jockeying for position to come last in appearing at the hearing because he wants to be sure he has got the last word on what the other fellow said. I would hope that could be avoided.

CHAIRMAN PAGLIN: I think those are significant comments and I thank you for them. In fact, they seem to be at base contemplated by the supplemental notice and I quote to you from the notice and this is the notice of December 27, I believe. Yes, the supplemental notice in which [48] the Commission contemplated that — and I am quoting, "Relevant written statements may be received for the record and those participating may, depending upon the number of requests received and the time available, be permitted to make brief oral statements of their views either in addition to or in lieu of written submissions."

Again going back to my opening remarks, it is my understanding of the intention of the Commission that written comments on the survey, on the proposed amendments, to wit the alternatives, were to be filed by January 15.

It seems to me the Commission contemplated this would be a legislative type hearing, oral presentation, which would be in addition to the written submission and would permit the highlighting of the main points of the written submissions and permit the Board to question — in order to point up the issues. It is true we will be faced with the dilemma about the situation that you have described and Dr. Steindler has indicated one of the things that should be followed in making this a more meaningful and expeditious

record. It may be that the Board may find it necessary to prescribe that written submissions be put in before the oral hearing and then proceed the way the Commission wanted us to proceed.

We will have to take that under advisement. I understand the problems of the organizations which have indicated [49] they have got problems in preparing this stuff in time, and it may be that the time schedule may have to allow itself some flexibility. I don't know yet.
[50]

MR. ROISMAN: Mr. Chairman?

CHAIRMAN PAGLIN: Mr. Roisman?

MR. ROISMAN: If I could, I would like to indicate — perhaps there has been misunderstanding on what we have been doing and I hope this will respond to the questions by Dr. Steindler and Dr. Geyer — we do intend, at least within the time frame that you indicated at the commencement of the hearing today, 48 hours before the commencement of the oral hearing, to give a fairly detailed statement of what our "position" is. I think Mr. Upton put it our position in chief; what we will not be prepared to submit at that time simply because of the technical problems of getting this together and putting it in the final form is the completed document, something that will look like this in form, which will incorporate into it our comments on the various positions taken by parties at the hearing and so forth, and try to represent the definitive position of our two groups, National Intervenors, and Union of Concerned Scientists.

I should hope the Board will be well aware of not only the areas which I gave you this morning, but also our position with respect to each of those areas and the major

questions and concerns that we have in those areas well in advance of the hearing.

Secondly, no matter what witnesses we bring down, they will be more than well qualified to answer the [51] questions in the area in which they are testifying. It happens that in several areas we have more than one person working and the chief person may not be available, but someone who's been available — but someone who's been working with that person will be available. Certainly we will not be bringing down witnesses who cannot respond to questions asked by the Board in the technical area that is pertinent to that particular area.

Finally, the written document that will be submitted both before the hearing, as well as the final one, will stand on its own. It will not be — not need to be referenced other than references in the technical document outside of the purposes of this proceeding.

CHAIRMAN PAGLIN: Mr. Gleason wanted to be recognized, I thought? No?

Okay. Mr. Freeman.

MR. FREEMAN: Mr. Chairman, since in our written document we made certain procedural recommendations which the Board had contemplated and indeed addressed itself to, and we have discussed some of the procedures to be followed, I just simply would like to make certain on the record that we correctly understand the position of the Board.

The Board indicated that while questions and answers by participants and the general Staff would not be appropriate to this hearing, to the extent, I believe the Chairman said, [52] the participants want to raise questions or have concerns, they may reflect them in their written comments,

in their oral comments, and in the supplemental written statements.

I would hope that the Board in fashioning any requirement for the submission of written statements in advance of oral statements, would still permit parties the flexibility to voice concerns which may have been raised in the interim.

CHAIRMAN PAGLIN: Oh, yes.

MR. FREEMAN: About statements by other persons, and indeed if they still have concerns that are voiced in the supplemental written statements and in the opinion of the Board these raise substantial factual situations, it seems to me the Board, as the Chairman just indicated, might entertain a further hearing session if it felt that the record needed supplementing on this line, so that the concerns, legitimate concerns of everyone, could be covered both in terms of being expressed and answered in substance on this record; and that would be a help to the Commission and to the public.

CHAIRMAN PAGLIN: Thank you, Mr. Freeman. I take it you were making reference to the document you handed me this morning?

MR. FREEMAN: Yes, sir.

CHAIRMAN PAGLIN: Yes. We will keep that in mind, [53] the points you make.

Are there any other comments by the participants? Mr. Gleason?

MR. GLEASON: Mr. Chairman, there is an issue item that has come up in our thinking about the position we might take with respect to alternatives one and two. I addressed a letter to Mr. Muncie on January 9 which I re-

gret I did not also send to the Board. I did not do it because it was in the nature of asking a clarifying question. Basically it deals with the interpretation which the Regulatory Staff puts on alternative one and I think it would serve — save a great deal of time in the oral presentations if the Staff was prepared to state its position on the interpretation of alternative one, either at this time or at some time prior to the start of the hearing, because otherwise I think we will spend a great deal of time in oral discussion trying to figure out what the Staff's position is.

CHAIRMAN PAGLIN: Mr. Murray, would you respond?

MR. MURRAY: I think I can help Mr. Gleason on that, Mr. Chairman. There is an error in the alternative number one. Looking at the reprint from the Federal Register, page 24192, containing the notice of proposed rulemaking, looking at the third column where alternative one appears, going to the middle of that column to the end of alternative one, that is, and counting up, one, two, three, four, five, [54] six, seven, eight lines, there is a line that begins, "Cycle and when factored into the cost," the "when" appearing in that line should be an "if."

This is a substantive change in the nature of alternative number one. It is the original intention.

MR. GLEASON: Would you also change the "are" in the next line to "would be"?

MR. MURRAY: If I were a stickler for proper English, I would.

(Laughter.)

CHAIRMAN PAGLIN: And you are changing it, right?

MR. MURRAY: I shall.

(Laughter.)

MR. GLEASON: Thanks a lot.

Mr. Chairman, I take it that, therefore, that there is no need in the hearing for us to address ourselves to alternative one in its uncorrected version. We will just assume, for purposes of the hearing, that it reads as it was just corrected.

CHAIRMAN PAGLIN: And all other participants may so regard it as well.

Mr. Roisman?

[55]

MR. ROISMAN: Mr. Gleason's question seems to raise a point that I am not sure we need to get into, in the hearing. As I understand it, whatever the Staff may have thought Alternative One meant, any party is free to suggest yet a third alternative to the Staff or to explain how they would be interpreting Alternative One or Two, if they were supporting them, or opposing them.

I take it we are not being faced with a fait accompli by the Commissioner, did I understand that to be the nature of the hearing which is that they said, you must choose between Alternative One or Two.

If you don't like it, that is tough.

They are willing to consider an Alternative Three, Four, Five, or Six.

Secondly, if I understand what the Board has indicated will happen after this prehearing conference is over, that the Board will issue a statement identifying the people who will testify at the hearing or rally, the amount of time

given, and for our purposes, I hope a specified time when that will happen; a day certain, and within some amount of leeway, a time certain, on that particular day.

Quite to the contrary of what Mr. Upton suggested, we have no interest in going last. If he prefers, we would be happy to go first, deferring, of course, to the Staff's general desire to do so.

[56]

All we need to know is, since we are bringing a lot of people in from out of town, we need to know what day we are going to go. When we know that, we can schedule accordingly.

Am I correct in assuming that is what the Board will be doing after this hearing?

CHAIRMAN PAGLIN: You have anticipated, correctly, Mr. Roisman.

My next point is to close the session, if there were not anything else.

That is, the Board will issue a further notice, as soon as possible in order to give the participants as much advance notice as possible.

What we propose to do is set up schedules, if we can, devoted to day and date and time, if we can organize them, in a logical manner, for the convenience of the parties; and also for the making of a decent record.

We will indicate in this notice, the time to be allotted to each group, participant, or individual.

I might indicate if there is nothing else, or no other questions, just by way for the record, the record that is being made; the transcription of the proceedings this morning, will not be made a part of the record in the pro-

ceedings, the formal record, which the Commission has requested be certified to it.

[57]

Our purpose in holding this session was, as I have indicated, and what has begun to come out, and that is for the convenience of the Board and the participants and in order to organize an effective and expeditious proceeding.

We don't see the need at this stage, to make this a formal part of the record, which will be certified.

If there are no other comments, I just want to indicate, for the record, the Board will apparently without objection, grant the request for extension of time by Sierra and Natural Resources defense counsel, for a reasonable extension of time.

I think I indicated it was either ten days or two weeks.

If there is nothing else, this procedure planning session — I see Mr. Murray?

MR. MURRAY: I thought it might be useful to remind everyone here that the hearing itself, is, I believe, in the room next door.

CHAIRMAN PAGLIN: Thank you for reminding me.

It will be in this area, but it will be in the Closed-Conference Room, next door, at 10 a.m.

Mr. Freeman?

MR. FREEMAN: Mr. Chairman, I hope the Board will reconsider its decision about not having this — the transcript of this prehearing conference made a part of the official record.

[58]

I think it would be important that it be so, because the Board has, in further discussions this morning, illuminated

and clarified the extent to which people will be permitted to participate and the ways in which the substantive concerns that they have, might be clearly put before the Board, and made a part of this proceeding, and I think that, if, at some future date, a court is concerned with the procedural interface of this rule-making and the procedures being followed by the Commission here, with individual licensing cases, it will be very helpful to have that part of the record.

CHAIRMAN PAGLIN: Well, you raise a good point, Mr. Freeman. I say, initially, it was our intention that this was for the convenience of the Board, so that we would have an accurate record of what the understandings were, and so on.

The point you raise is a reasonable one. It may very well be that it may serve a purpose, making it part of the record.

We can take that under advisement. I don't feel strongly, one way or the other. As I say, it was our intention, this being a rather novel procedure, that we had intended this to be kind of informal, and as I say, for purposes of accuracy, to have a record made.

I don't, at this stage, see any basic objection. We will take it under advisement.

MR. FREEMAN: Thank you, very much.

[59]

CHAIRMAN PAGLIN: All right, if there is nothing else, I thank all of you for coming, and you will be hearing from us by way of formal notice, soon.

Thank you, again.

(Whereupon at 11:20 a.m., Wednesday, January 17, 1973, the Prehearing was adjourned.)

[60]

UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

IN THE MATTER OF:	Docket No. RM-50-3
URANIUM FUEL CYCLE	

New Executive Office Building
Room G2008
17th & H Streets
Washington, D. C.

Thursday, 1 February 1973

The above-entitled matter came on for hearing, pursuant to notice, at 10 a.m.

BEFORE:

M. D. PAGLIN, ESQ., Chairman.
DR. JOHN C. GEYER, Member.
DR. M. J. STEINDLER, Member.

APPEARANCES:

(As heretofore noted.)

ADDITIONAL APPEARANCES:

ARVIN E. UPTON, ESQ. and JAMES P. MC GRANERY, JR., ESQ., Lebauf, Lamb, Leeby & MacRae, 1821 Jefferson Place, N. W., Washington, D. C., on behalf of Alabama Power Company, et al.

[61]

CONTENTS

STATEMENT OF:

	Page [OF TRANSCRIPT]
S. H. Smiley, Deputy Director for Fuels and Materials — Directorate of Licensing, Regulatory Staff, Atomic Energy Commission	72
Dr. Frank K. Pittman, Director, Division of Waste Management & Transportation, USAEC	96
W. D. Rowe, on behalf of the U.S. Environmental Protection Agency	151
Steve J. Gadler, P.E., St. Paul, Minnesota, on behalf of the Mapleton Intervenors of Midland, Michigan	165
Peter A. Lindley, Assistant to General Manager, Nuclear Fuel Division, Westinghouse Electric Corporation	190 199
Anthony A. Roisman, on behalf of the Consolidated National Intervenors and the Union of Concerned Scientists, accompanied by	206
Dr. Edward P. Radford, and	219
Dr. Henry W. Kendall	263

[62]

PROCEEDINGS

CHAIRMAN PAGLIN: Good morning, ladies and gentlemen. May we come to order. This is an informal rulemaking hearing in Docket RM-50-3, which is being held pursuant to notice of proposed rulemaking published in the Federal Register on November 15, 1972, by the Atomic Energy Commission. The Commission's notice of proposed rulemaking concerns possible amendments to Part 50, Appendix D of its rules, which would deal specifically with the question of consideration of environmental effects associated with the uranium fuel cycle and the individual cost/benefit analyses for light water cooled power reactors.

In conjunction with this rulemaking, the Commission's Regulatory Staff at the same time issued for comment and environmental survey of the effects associated with producing the annual requirements for uranium nuclear fuel of a model light water cooled reactor, capable of producing 1,000 megawatts of electricity.

The environmental survey, which was to serve as the basis for the rulemaking hearing, describes the effect of each stage of the cycle, from the mining and milling of natural uranium to the ultimate disposal of high-level radioactive wastes resulting from reprocessing of the used fuel.

The notice of rulemaking invited the comments of [63] interested persons and scheduled an informal rulemaking hearing on February 1, 1973, to permit the presentation of views, both oral and written, on two alternative approaches to consideration of the environmental effects of the uranium fuel cycle and environmental statements in terms of possible amendments to Part 50.

The alternatives were set out in the Commission's notice of November 15. It is to be noted for the record that the language of Alternative 1 is to be considered amended, in accordance with a letter dated January 22, 1973, from Mr. Murray of the Regulatory Staff, in the following respects: The language to be amended appears in the right-hand column of page 24192 of the Federal Register of November 15, 1972, and concerns the revision of language in the penultimate sentence in paragraph (1).

The latter part of that sentence as amended will read, "Activities as related to a particular light water cooled nuclear reactor have been analyzed in the Commission's environmental survey of the nuclear fuel cycle, and if factored into the cost/benefit analysis, would be sufficiently small as not to affect significantly the resultant conclusion."

Thereafter in a supplemental notice of rulemaking issued on December 27, 1972, the Commission set forth the procedural conditions which would be followed in this [64] informal legislative type rulemaking hearing. It was specified, among other things, that since this would be part of a rulemaking rather than an adjudicatory proceeding, the provisions of subpart (g), "Rules of General Applicability," of Part 2 of the Commission's rules of practice, would not be applicable and that no discovery or cross-examination would be utilized in this proceeding. However, the notice provided that the participants in the hearing would be subject to questioning by the presiding Hearing Board.

Thereafter, on January 17, 1973, and pursuant to the supplemental notice, to authorization in the supplemental notice, the Hearing Board named by the Commission conducted a procedure planning session at which all participants in this proceeding were invited.

As a result of that session, a further notice of rulemaking hearing was issued by the Hearing Board on January 19, setting forth, among other things, the schedules of appearances for participants who are to make oral presentations, in addition to written submissions, and a statement of the understandings and agreements expressed by the participants at that session.

There was attached to that further notice of hearing a list of names and addresses of all of the participants who had filed statements in this proceeding, and it was agreed by those present that the written submissions to [65] be offered by the participants would be provided to the other participants in ths proceeding named on the list.

Subsequent to the issuance of the further notice of hearing, certain changes were made in the schedule for appearances set out in that notice by the agreement of the participants and the consent of the Board. The principal change is that the Consolidated National Intervenors and the Union of Concerned Scientists will make their presentation on the afternoon of Thursday, February 1, that is today, instead of their previously scheduled appearance on Friday morning, it having been agreed among the parties that they would exchange positions with the Thursday afternoon scheduled participants.

In addition, I have been advised by Mr. Dzugan of the Minnesota Pollution Control Agency that he will appear at the conclusion of the session on Friday, February 2, in lieu of his scheduled appearance this morning.

In commencing this rulemaking hearing, the Board has determined the following documents shall be incorporated by reference in the record of this proceeding, as though they had been set forth at length at this point in the pro-

ceeding, namely, the Commission's notice of proposed rulemaking, published in the Federal Register on November 15, 1972; the environmental survey of the nuclear fuel cycle issued by the Regulatory Staff of the Commission; the [66] Commission's supplemental notice of rulemaking hearing issued December 27, 1972; and the further notice of rulemaking hearing issued by the Hearing Board on January 19, 1973.

I would like now to call for the appearances of the participants and their counsel, if they are accompanied by counsel, in the order in which they appear in the January 19 further notice of hearing. And thereafter, I will ask for appearances by any others who wish to make oral presentations and for whom provision has not been made in the further notice of hearing. However, it is to be understood, of course, that these latter will be heard if time is available in the sessions that have been scheduled for the next two days.

May I now, for the record, have the appearances of the Regulatory Staff of the Commission.

MR. MURRAY: Mr. Chairman, my name is James Murray; I am appearing as counsel for the Regulatory Staff of the Commission. Our principal witnesses are with me here at the table. We will have back-up personnel to help them in response to any questions the Board may ask. The principal witnesses are, immediately to my left, Mr. S. H. Smiley, and two persons removed, Dr. Frank Pittman.

CHAIRMAN PAGLIN: Thank you, Mr. Murray.

Next on the schedule in the further notice is [67] listed General Electric Company. We have been since advised that they do not desire to make an oral presentation, but will

be present for questioning. Is there an appearance for General Electric?

MR. RESTRICK: John Restrick, counsel for General Electric. We do have people here who can answer questions of the Board if they have any.

CHAIRMAN PAGLIN: Thank you, Mr. Restrick.

Next, U. S. Environmental Protection Agency. Is there someone present from EPA?

(No response.)

CHAIRMAN PAGLIN: We will check later on. I mentioned, but I will have the appearance now, the Minnesota Pollution Control Agency, I believe Mr. Dzugan is here now.

MR. DZUGAN: My name is Ken Dzugan, and I am here on behalf of the Minnesota Pollution Control Agency.

CHAIRMAN PAGLIN: Mr. Steve J. Gadler.

MR. GADLER: Mr. Chairman, I am Steve J. Gadler. I am here from St. Paul, Minnesota. I represent the Mapleton Intervenors and myself at this hearing.

CHAIRMAN PAGLIN: Thank you, Mr. Gadler.

Westinghouse Electric Corporation.

MR. DAUGHERTY: I am Thomas Daugherty, Westinghouse, and our principal witness, Mr. Peter Linley, is present.

CHAIRMAN PAGLIN: On behalf of the National [68] Intervenors and Union of Concerned Scientists.

MR. ROISMAN: Anthony Z. Roisman. I am appearing on behalf of the Consolidated National Intervenors and the

Union of Concerned Scientists. Our two technical witnesses will be here this afternoon, Dr. Henry Kendall, Dr. Henry Radford.

I would like to make a correction. In response to a question by Dr. Geyer, we sent in a list of the participants, and the name of the Mapleton Intervenors was included in that list interested, inadvertently. As you heard, Dr. Gadler is here and will be speaking on their behalf.

CHAIRMAN PAGLIN: Thank you, Mr. Roisman. The record will be corrected accordingly.

Going back up again, the Atomic Industrial Forum, Inc.?

MR. WIGGIN: I am Edwin Wiggin. I am with the Forum; I will be making a statement tomorrow morning. I will be accompanied by counsel, who is not yet here.

CHAIRMAN PAGLIN: Thank you, Mr. Wiggin.

Next on our list is Exxon Nuclear Company. They have also advised us that they do not desire to make an oral presentation, but will have someone present. Are they here?

MR. NILWON: Roy Nilson, representing Exxon Nuclear. We would like to have our written statement entered [69] into the record.

CHAIRMAN PAGLIN: Yes. Exxon has submitted a statement and it will be considered introduced into the record at this point.

S. M. Stoller Corporation.

DR. GELLER: I am Leonard Geller from S. M. Stoller Corporation. I will not be making an independent submittal or oral presentation. I will, instead, be working with the 14 utility group represented by Mr. Freeman.

CHAIRMAN PAGLIN: So, as I understand it, you will not make an individual oral presentation?

DR. GELLER: That is correct.

CHAIRMAN PAGLIN: Thank you.

Now, skipping down, Baltimore Gas & Electric Company and the other named utility companies appearing jointly.

MR. FREEMAN: George C. Freeman, Jr., of Hunton, Williams, Gay, Powell & Gibson of Richmond, Virginia, appearing here on behalf of that group of utilities, accompanied by Mr. David Brollier of my firm. Also Dr. Leonard Geller of S. M. Stoller Corporation is assisting us as a technical expert.

CHAIRMAN PAGLIN: Next, the New York State Atomic Energy Council. Do we have an appearance for them this morning?

[70]

MR. CASHMAN: Thomas J. Cashman, appearing on behalf of the New York State Department of Environmental Conservation. I anticipate counsel from the Atomic Energy Council will be here tomorrow. In view of the changed schedule, I cannot guarantee he will make it.

CHAIRMAN PAGLIN: Thank you, sir.

That completes the list of participants named in the notice of January 19 who sought the privilege of oral presentation.

Are there any other persons present today who are not listed, who were not here at the planning session on January 17, who would wish to make an oral presentation, provided time will be available? If so, can you state your name and your affiliation?

MR. ROWE: I wasn't here when you called the roll, but W. D. Rowe from EPA.

CHAIRMAN PAGLIN: Thank you. You will be appearing this morning, Mr. Rowe.

MR. ROWE: Yes.

CHAIRMAN PAGLIN: Hearing no response to my earlier question about additional oral presentations, we will now move along.

The first appearance, on behalf of the Regulatory Staff of the Commission, I will call on Mr. Murray.

MR. MURRAY: Yes, Mr. Chairman. Thank you very [71] much. Mr. Smiley will present the opening statement of the Commission, and followed by Dr. Pittman, who will address himself to the subject of high level waste disposal. Since we do have a number of back-up personnel here, who will possibly be answering questions, I am wondering if I shouldn't submit, for the record, at this time, the statements of qualifications of all of our people, including Mr. Smiley and Dr. Pittman, and the back-up folks, and have them incorporated in the record physically as if read.

CHAIRMAN PAGLIN: Without objection, Mr. Murray, they will be accepted.

(The documents follow.)

DONALD A. NUSSBAUMER
U.S. Atomic Energy Commission
Washington, D.C. 20545

EDUCATION

BS	Chemistry-biology	Union College, Schenectady, N.Y.	1950
1 Yr. Graduate Work	Biochemistry	Cornell University, New York, N.Y.	1951

EXPERIENCE

1972 to date	Assistant Director for Fuel Cycle	Directorate of Licensing U.S. Atomic Energy Commission Washington, D.C. 20545

Plan, direct and supervise nonreactor fuel cycle licensing activities of the AEC Regulatory program as carried out by the following Branches — Fuel Fabrication and Reprocessing, Transportation, Technical Support, and Materials and Plant Protection. Activities include licensing of nonreactor production and utilization facilities, including their operators, licensing of special nuclear material in quantities greater than a critical mass, approval of radioactive material shipping containers, approval of controls for safeguarding strategically important nuclear materials against diversion and protection against acts of industrial sabotage, and assessment of environmental impact of fuel cycle plants pursuant to the National Environmental Policy Act.

1970-1972	Chief, Fuel Fabrication and Transportation Branch	Division of Materials Licensing U.S. Atomic Energy Commission Washington, D.C. 20545

Administer the technical evaluation and processing to final action all applications for and communications concerning licenses for special nuclear material in quantities greater than a critical mass. Administer the evaluation and approval of proposed designs of shipping casks for transportation of irradiated reactor fuel elements and other radioactive material from the standpoint of their adequacy to comply with regulatory standards.

1961-1970 — Chief, Source and Special Nuclear Materials Branch — Division of Material Licensing, U.S. Atomic Energy Commission, Washington, D.C. 20545

Administer the technical evaluation and processing to final action of all applications for and communications concerning licenses for source material and special nuclear material.

1957-1961 — Radiation Safety Specialist — Division of Licensing and Regulations, U.S. Atomic Energy Commission, Washington, D.C. 20545

Evaluation of potential radiation hazards associated with the use, storage, disposal, and transport of radioactive materials and the adequacy of engineering and administrative controls to protect against such hazards. Assists in the development of criteria, standards and operating procedures in radiation protection for use in establishing regulations and evaluating license applications.

1955-1957 — Field Representative — Oak Ridge Operations Office, U.S. Atomic Energy Commission, Oak Ridge, Tennessee

Visited firms and institutions licensed by the AEC to use radioisotopes. Advised radioisotope users in special radiation protection problems involving shielding, monitoring, instrumentation, laboratory design, ventilation and waste disposal. Checked programs to determine compliance with proper radiation safety practices.

1951-1955	Senior Health Physics Inspector	Knolls Atomic Power Laboratory General Electric Company Schenectady, New York

Health physics responsibilities in environmental monitoring, chemical processing of irradiated uranium, radiochemical research laboratories. Also health physics responsibilities in reactor design, startup, operation and refueling. Duties included evaluation of facility and equipment design, radiation monitoring, and establishing administrative controls for radiation safety.

SIGNIFICANT PUBLICATIONS

"Safety Controls Over Uses of Radioactive Materials." Symposium on the Administrative and Regulatory Problems Connected with Atomic Energy Programs — University of Puerto Rico — 1959.

"USAEC Regulatory Control Program for Uranium Milling." International Symposium on Radiological Health and Safety in Mining and Milling of Nuclear Materials — International Atomic Energy Agency — Vienna, Austria — 1963.

MILITARY STATUS

1946 to 1948	Veteran	U. S. Army Medical Corps

PERSONAL

U.S. Citizen	Born October 15, 1927
Married	5 Children

THEODORE R. WORKINGER
USAEC, Bethesda, Md.

EDUCATION

BS	Chemical Engineering	Univ. of Wisconsin	1950

EXPERIENCE

1968 to present	Fuel Fabrication & Reprocessing	Fuels & Materials Div. Regulatory, USAEC

Primary responsibility is the evaluation of the engineering and radiological safety design criteria and design bases for the proposed Barnwell Nuclear Fuel Plant.

1961 to 1968	Chemical Processing	USAEC

Assisted the development and implementation of programs and policies for Government and industrial activities in the chemical reprocessing segment of the nuclear fuel cycle. Overall staff responsibility for program planning, budgeting and management of the AEC's research and development programs, projects, and production operations pertaining to the chemical processing of irradiated reactor fuels and target materials to recover, purify, manufacture and supply special nuclear materials, fission products, transuranic products and other radioisotopes, at the AEC's separation facilities at Hanford, Idaho and Savannah River. Responsible for assisting technical exchanges with international visitors.

1958 to 1961	Division of Isotopes Development	USAEC

Responsible for administering the Commission's radioisotope production and distribution program. Implemented the development of solvent extraction processes

for the recovery, separation and purification of fission products and other radionuclides, the development of methods to ensure the safe shipment of large quantities of fission products and the development of technology for manufacturing large sealed sources for isotopic power and radiation applications.

1950 to 1958 General Electric — Hanford Atomic Prod. Operation

Shift supervision responsibilities for operations in chemical separation plants, the plutonium fabrication facility and the UO_3 conversion facility. Staff responsibility also for operator safety training, production planning and scheduling, nuclear materials management, and plant maintenance. From 1952 to 1955 senior process engineer with responsibilities for assisting with supervisor and operator training, preoperational testing, and the startup of the Redox plant, the TBP plant, and the Purex plant. In 1955, appointed Group Leader of the Process and Engineering Unit, with responsibilities for providing process engineering services to ensure the overall performance and safety of the Purex plant at Hanford. Promoted to Engineering Analyst, with responsibilities for technical evaluation and economic analysis of proposed new capital projects, and directly assisted the Manager of the Facilities Engineering Operation, Chemical Processing Department, with management studies directed toward improving the effectiveness of the design, engineering and project management components reporting to him.

NELSON R. LEIST
National Lead Company of Ohio
P. O. Box 39158
Cincinnati, Ohio 45239
Telephone 513 738-1151

EDUCATION

Chem. Eng. Degree	Chemical Engineering	University of Cincinnati	1954
Juris Doctor Degree	Law	Chase College	1961

EXPERIENCE

1966 to date — Supervisor — Production Technology-Chemical Group, National Lead Co. of Ohio

Responsible for the development of process improvements and new processes for the conversion of uranium concentrates into cascade feed materials. Duties include work associated with processes and procedures necessary for environmental protection. Specifically in the field of water and air contamination by chemical pollutants and radionuclides from the refining processes.

1961 to 1966 — Section Leader — Chemical Department, National Lead Co. of Ohio

Supervision of a section responsible for the devlopment of new processes and procedures associated with the liquid-liquid extraction of uranium and thorium.

1956-1961 — Technologist — Chemical Department, National Lead Co. of Ohio

Pilot Plant and production testing of liquid-liquid extraction processes.

PUBLICATIONS

J. F. Blum, R. H. Ellerhorst, C. W. Huntington, J. H. Krekeler, N. R. Leist, J. R. Nelli, and M. D. Snyder, "*Refining of Thorium-containing Uranium Concentrates by Extraction with Tributyl Phosphate,*" USAEC Report, NLCO-692, August 29, 1957

N. R. Leist, "*Evaluation of a Coalescer-De-Entrainer Unit,*" USAEC Report, NLCO-725 (p. 29-34), April 18, 1958

C. T. Hicks, N. R. Leist, and J. R. Nelli, "*Laboratory and Pilot Plant Evaluation of Stanrock Uranium Concentrate,*" USAEC Report, NLCO-762, October 10, 1958

N. R. Leist and J. R. Nelli, "*Raffinate Mixer-Settler for the Primary Extraction Columns,*" USAEC Report, NLCO-805 (p. 13-21), April 29, 1960

J. H. Krekeler and N. R. Leist, "*Removal of Foreign Materials from the Refinery TBP Solvent,*" USAEC Report, NLCO-882, June 25, 1963

R. C. Kispert and N. R. Leist, "*Computerized Control of Nuclear Materials for Uranium Residue Reprocessing,*" USAEC Report, NLCO-1017, May 3, 1968

J. H. Cavendish, R. C. Kispert, N. R. Leist and G. P. Miller, "*Crystallization Characteristics of Acid Uranyl Nitrate Solutions,*" Nuclear Applications, 5:224, 1968

N. R. Leist, "*The Beneficiation and Refining of Uranium Concentrates,*" USAEC Report, NLCO-1067, April 23, 1970

R. C. Kispert, N. R. Leist, and A. F. Pennak, "*Reduction of Nitrogen Oxides in Vent Gases by Scrubbing,*" USAEC Report, NLCO-1094, October 20, 1972

ROBERT G. JORDAN
Union Carbide Corporation — Nuclear Division
P. O. Box Y
Oak Ridge, Tennessee 37830
Telephone: 615 483-8611, Ext. 3-5164

EDUCATION

B.S.	Chemistry-Physics — Ohio State University	1942

EXPERIENCE

1972 to date	Manager of Safety and Environmental Protection	Union Carbide Corporation Nuclear Division
1963 to 1972	Plant Superintendent Oak Ridge Gaseous Diffusion Plant	UCC-ND
1961 to 1963	Plant Superintendent Oak Ridge Y-12 Plant	UCC-ND
1954 to 1961	Plant Superintendent Paducah Gaseous Diffusion Plant	UCC-ND
1951 to 1954	Operations Superintendent Paducah Gaseous Diffusion Plant	UCC-ND
1947 to 1951	Process Engineering Department Head Oak Ridge Gaseous Diffusion Plant	UCC-ND
1943 to 1947	Process Engineer — SAM Laboratories and Oak Ridge Gaseous Diffusion Plant	UCC-ND
1942 to 1943	Engineer	Sanderson & Porter

VIRGIL S. EMLER
P. O. Box 628
Piketon, Ohio 45661
Telephone: (614) 289-2331

EDUCATION

B.S.	Met. Engr.	Carnegie-Mellon Univ.	1950

EXPERIENCE

1971 to present	Supervisor, Environmental Control Corporate responsibility for environmental control and pollution abatement.	Goodyear Atomic Corp.
1967-1971	Supervisor, Special Projects Coordination and evaluation of development laboratory projects.	Goodyear Atomic Corp.
1963-1967	Supervisor, Chemistry Dept. Developmental chemistry for gaseous diffusion process. IR Spectroscopy, spectrography, and electron microprobe labs.	Goodyear Atomic Corp.
1956-1963	Supervisor, Metallurgy Dept. Developmental metallurgy for diffusion plants. Failure-analysis lab.	Goodyear Atomic Corp.
1953-1956	Metallurgist Failure analysis.	Goodyear Atomic Corp.
1952-1953	Metallurgist Technical assistance to vendor foundries.	North American Aviation (North American-Rockwell)
1951-1952	Metallurgist Alloy development.	Battelle Memorial Institute
1948-1951	Metallographer, Metallurgist Metallography, heat-treatment studies.	Vanadium Corp. of America

Educational and Professional Qualifications

ROBERT F. BARKER
Chief, Product Standards Branch
U.S.A.E.C.

My name is Robert F. Barker. I am Chief of the Product Standards Branch of the Directorate of Regulatory Standards of the U. S. Atomic Energy Commission, 7920 Norfolk Avenue, Bethesda, Maryland. Since assuming this position in January 1961, I have been responsible for the formulation of policy and development of regulatory safety standards, criteria, rules and regulations for the transportation of byproduct, source and special nuclear material in the Commission's licensing program. During the past 11 months, I have been responsible for preparation of the sections on transportation in about 30 environmental statements for individual nuclear power plants.

I received a Bachelor of Science in Electrical Engineering from Ohio University in 1949. I did graduate work toward a Master of Science degree in radiological physics on an AEC fellowship at the University of Rochester in 1949-50, which I received in 1953.

I was employed by the University of California at the Los Alamos Scientific Laboratory from 1950 until 1955. As assistant Leader of the General Monitoring Section, I was responsible for the monitoring operations at nuclear weapons tests, around the test reactors and for shipments coming to or leaving the Laboratory. While in that position, I compiled and edited the first General Monitoring Handbook.

In 1955, I joined the AEC as assistant Chief of the Radiation Safety Branch of the Isotopes Division and, except for the years 1959 and 1960, I have been with the Commission since that time. During 1959 and 1960, I was employed on the Staff of the International Atomic Energy Agency as a Senior Health Physicist in the Division of Health, Safety, and Waste Disposal. As part of my duties for the IAEA, I was the Secretary to the Panel of Experts called together by the Agency to establish International Standards for the Safe Transportation of Radioactive Materials.

In subsequent meetings of Panels of Experts on Transportation of Radioactive Materials organized by the IAEA, in 1963, 1964, 1970 and 1971, I represented the AEC as participant or advisor to the designated participant.

I am a Health Physicist certified by the American Board of Health Physics.

I am a member of the Health Physics Society, the American Society for Quality Control and the Society for Non-Destructive Testing.

I am author of the Chapter on "Radiation Protection" in the Handbook on Non-Destructive Testing, an A.S.T.M. publication, co-author of a Chapter in the "Safe Transport of Radioactive Materials" edited by Roy Gibson and have written several technical papers on safety in transportation.

JOE DYKSTRA
P. O. Box P
Oak Ridge, Tennessee 37830
Telephone 615 483-8611, Ext. 3-3306

EDUCATION

A.B.	Chemistry	Grinnell College	1943

EXPERIENCE

1943-1945 Hooker Chemical Company, Niagara Falls
Manhattan District — Fluorine and Flurocarbon
Development and Production.

1945 to date Union Carbide Nuclear Division — Oak Ridge
Gaseous Diffusion Plant.

Operations Division Supervisory assignments in gaseous diffusion cascade operqtions, equipment decontamination, uranium recovery, fluorine production. Oxide to UF_6 production, utilities production and distribution such as steam, air, potable and recirculating cooling water and diffusion plant environmental control.

Currently, Chemical Operations Department Superintendent responsible for receipt and shipment of toll enrichment feed and product and diffusion plant equipment decontamination and uranium recovery.

PUBLICATIONS

AEC publications on Fluorine Production and Uranium Recovery.

IRVIN G. SPEAS
Union Carbide Corporation — Nuclear Division
P. O. Box Y
Oak Ridge, Tennessee 37830
Telephone: 615 483-8611, Ext. 3-5164

EDUCATION

B.S.	Mechanical Engineering —	Duke University	1949
Graduate Study	Math & Mech. Eng. Courses	University of Tennessee	1955-58

EXPERIENCE

1972 to date	Engineering Consultant	Union Carbide Corporation Nuclear Division Office of Safety and Environmental Protection Oak Ridge, Tennessee

This office is responsible for the coordination of the safety and environmental programs at the Oak Ridge National Laboratory, Oak Ridge Gaseous Diffusion Plant, Paducah Gaseous Diffusion Plant, and the Oak Ridge Y-12 Plant.

1957 to 1972	Department Superintendent	Union Carbide Corporation Nuclear Division Design Engineering Oak Ridge Y-12 Plant

Responsible for engineering studies of plant facility requirements, design of special process equipment, plant budget justification documents, design of process and utility piping systems, and environmental pollution abatement studies and designs.

1949 to 1957	Design Engineer	Union Carbide Corporation Nuclear Division Design Engineering Oak Ridge Y-12 Plant

Design of process and utility systems and associated pumps, compressors, heat exchangers, stills, and cooling towers.

ENVIRONMENTAL POLLUTION CONTROL ASSIGNMENTS

1967 to 1972 — Y-12 Plant representative on the AEC-ORO Environmental Pollution Task Force. This group is responsible for the environmental programs at the AEC facilities in Oak Ridge, Tennessee; Paducah, Kentucky; Cincinnati, Ohio; and Portsmouth, Ohio.

1970 to 1972 — Y-12 Plant representative on the Union Carbide Corporation — Nuclear Division Four-Plant Environmental Committee. This committee was responsible for apprising management of the extent and possible impact of the Division's operations upon the environment.

TECHNICAL PAPERS PRESENTED

"Survey of Municipal Refuse Incinerator Design Practices", presented before the AEC-ORO Environmental Pollution Task Force, July 13, 1967.

"Electrostatic Precipitators Versus Mechanical Collectors For Steam Plant Stack Emission Control", presented before the AEC-ORO Environmental Pollution Task Force, January 17, 1969.

"Environmental Pollution Control (Liquid, Gaseous, and Solid Wastes)", presented before the AEC National Plant Facilities Managers Meeting; Oak Ridge, Tennessee; March 14, 1969.

"Environmental Pollution Control at the Oak Ridge Y-12 Plant", presented before the Southeastern Industrial Health Conference; Gatlinburg, Tennessee; October 1, 1970.

"Experience with the Oak Ridge Centralized Sanitary Landfill", presented before the AEC Pollution Control Conference; Oak Ridge, Tennessee; October 26, 1972.

MILITARY STATUS

1944 to 1946	Veteran	U. S. Army Signal Corps

TECHNICAL SOCIETIES

Registered Professional Engineer, State of Tennessee

Member of Tennessee Society of Professional Engineers and the National Society of Professional Engineers

PERSONAL

U. S. Citizen	Born July 12, 1925
Married	Two Children
Height — 5'9"	Weight — 155 pounds
Excellent Health	No Physical Defects

WILLIAM H. RAY
USAEC, Bethesda, Maryland

EDUCATION

BA	Physics	State University of Iowa	1938

EXPERIENCE

1962 to present	Senior Health Physicist	Fuels & Materials Div. Regulatory, USAEC

Evaluation of the radiological safety provisions of irradiated fuel and radioisotope processing plants. Work has included the preparation of environmental statements, safety evaluations to justify the issuance of materials licenses for: laboratories utilizing hot cells, tests and usage of devices employing large quantities of radioisotopes as a heat source, and containers for the shipment of irradiated nuclear fuel and/or large quantities of radioisotopes.

1956 to 1962	Health Physicist	General Atomic

Organized and administered a health and safety program for the newly founded General Atomics Division of General Dynamics. Developed instruments as they became needed for special radiological safety applications, e.g., a stack gas beta activity monitor, a low background laboratory counter to simultaneously measure alpha and beta activity, and a variety of radiation alarms, some adapated to dealing with pulses from accelerators and thermonuclear experiments. Responsibilities included nuclear safety surveillance and material accountability, design of ventilation systems to control airborne radioactive particulates, operation of the radioactive waste collection and packaging service, and promulgation of radiological and industrial safety throughout the laboratory. Served as a member of the iso-

tope committee of a local hospital staff comprised the Radiological Assistance Team for San Diego county.

1955 to 1956 — Training Officer — U. S. Public Health

Conducted Radiological Safety courses for State Health Departments throughout the U. S. Helped to establish the fallout monitoring network, and worked with the Federal Civil Defense Agency in the initiation of a radiological safety training program, which included the forecasting of fallout patterns.

1954 to 1955 — Maintenance Engineer — Black Hawk Broadcasting

Installed, maintained and operated two television stations, and maintained two AM broadcast stations. Ran RCC proof of performance. Designed and built equipment to convert to color transmission.

1950 to 1952 — Research Associate — Graduate School of Public Health Univ. of Pittsburgh

Taught Radiological Physics and Health Physics, and provided health physics surveillance throughout the University of Pittsburgh and Carnegie Institute of Technology. Initiated a reasearch program to investigate the consequences of inhaling insoluble radioactive particulates. Served as a consultant to Westinghouse Electric Corporation's Atomic Power Division, and participated in Los Alamos Scientific Laboratory fallout studies in Nevada during two bomb test series.

1953 to 1954 — Engineer — Edgerton, Germeshauser & Grier

Responsible for the radiological safety program of EG&G, Inc. in addition to primary duties involving nuclear explosion diagnostic. During this period, developed and field tested a radiation measuring and telemetry system.

1944 to 1950 — Section Chief — Oak Ridge National Lab

Responsible for: all plant and environmental surveys, personnel monitoring, and instrument calibration. Played a primary role in establishing the objectives, developing the techniques, and evolving the basic principles of the health physics profession. Instituted radiological safety programs at the University of Chicago Metallurgical Laboratory, at Mound Laboratory, and at the San Francisco Navl Shipyard (which evolved into the U. S. Naval Radiological Defense Laboratory). Served as a consultant to AEC regarding radiological safety practices at uranium refineries, and made a field study of the residual activity and the particulate problem at Eniwetok, following the first test series at that atoll.

1941 to 1944 — Crystal Physicist — Collins Radio Co.

Developed new quartz oscillator control cuts, manufactured techniques and quality control procedures. Custom finished crystals and trained finishers.

1938 to 1941 — Heating & Air Conditioning Engineer — Checker Electric Supply, Inc.

Surveyed domestic and commercial buildings to determine heating and cooling needs. Designed heating and air conditioning systems, including duct work details. Supervised installations and responsible for attaining warranty performance.

PUBLICATIONS

"Letter to the Editor," (Concerning evidence of log-normal distribution of air sampling data and of personnel cumulative radiation exposure.) Health Physics, Vol. 9, p. 242, 1963.

"Stack Gas Beta Monitor," American Industrial Hygiene Association Journal, Vol. 23, pp. 496-502, 1962.

"Radiation Alarm Pedestal," American Industrial Hygiene Association Journal, Vol. 22, pp. 494-496, 1961.

"Protection of Livestock from Radioactive Fallout," Bremer County Independent, Waverly, Iowa, November 7, 1956.

AECU-565 "The Design of Radiochemical Laboratories."

AECD-2357 "Change and Eng. in Use."

MDDC-1502 "The Clinton Walkie Talkie and Scale of Two."

MDDC-40 "Health Physics Building Surveying at Clinton Laboratory."

Radiological Safety Manuals:

"A Manual of Radiological Safety Practices," The Donald N. Sharp Memorial Hospital, San Diego, California, 1959.

GA-417 "Radiological Safety at General Atomic," 1958.

"Health Physics Primer," Edgerton Germeshausen and Grier, Inc., Las Vegas, Nevada, 1953.

RALPH G. PAGE
USAEC, Bethesda, Md.

EDUCATION

B.A.	Chemistry and Math	Augustana College Rock Island, Ill.	1949-50 1951-54
	AEC Radiological Physics Fellowship	University of Washington Seattle, Wash.	1954-55
	Nuclear Engineering	University of Tennessee University of Maryland	Night School 1957-60
	Management	Federal Executive Inst. Charlottesville, Va.	8 weeks 1969

EXPERIENCE

1972 to present	Chief, Materials & Plant Protection Branch	U. S. Atomic Energy Commission Directorate of Licensing Washington, D. C.

Reviews applicant's materials security and plant protection procedures and issues license amendments, exemptions, and special conditions; assists in development of regulatory materials and plant protection policies and implementing regulations; evaluates effectiveness of applicable materials and plant protection requirements on a continuing basis.

1967 to 1972	Assistant Director for Licensing and Regulations	U. S. Atomic Energy Commission Division of Nuclear Materials Safeguards Washington, D. C.

Same as in present position.

1962 to 1967	Chief, Enforcement Branch	U. S. Atomic Energy Commission Division of Licensing and Regulation Washington, D. C.

Reviewed compliance inspection reports and initiated enforcement actions in cases where licensees were found out of compliance with applicable regulatory requirements.

1955-1962	Health Physicist	U. S. Atomic Energy Commission Oak Ridge, Tennessee and Washington, D. C.

Reviewed adequacy of radiation safety programs proposed and implemented by licensees for protecting the public against radiation hazards.

PUBLICATIONS

"Physical Protection of Special Nuclear Material in Transit", Conf. Transportation of Radioactive Material, University of Virginia, Charlottesville, October 1969 by Page, R. G.

"The Division of Nuclear Materials Safeguards — The Second Year", 11th Annual Meeting of Institute of Nuclear Materials Management, Gatlinburg, May 1970 by D'Amico, V. J., and Page, R. G.

"U. S. Safeguards Experience in Regulation and Inspection of the Private Nuclear Industry", Symposium on Safeguards Techniques, Karlsruhe, West Germany, July, 1972 by Wischow, R. P., D'Amico, V. J. Page, R. G., and Ong, L. D. Y.

NATHAN BASSIN
USAEC, Bethesda, Md.
Telephone 301-973-7463

EDUCATION

B.A.	Chemistry	Suffolk University	1951
	Chemistry	Boston College	1956

EXPERIENCE

1958 to date	Senior Reviewer	Materials Branch Directorate of Licensing, USAEC

Evaluation of applications for use of byproduct material. Review of applications for all areas of radioisotope use including review of applications for disposal of radioactive waste by land burial and burial at sea.

1958-1959	Reviewer	Materials Branch USAEC Division of Licensing and Regulation

Evaluation of applications for use of byproduct material.

1958	Physical Scientist	Canoga Park Area Office USAEC

Administration of contract of prime AEC-contractor. Review of health physics and materials management programs of contractor.

1955-1958	Reviewer	Isotopes Branch Oak Ridge Operations Office USAEC

Review of applications for use of byproduct material.

1952-1954	Chemist	Tracerlab, Inc. Boston, Mass.

Worked on classified Air Force project.

JACK E. ROTHFLEISCH
USAEC, Bethesda, Md.

EDUCATION

B.Ch.E.	Chemical Engineering	College of the City of N.Y.	1940
	Industrial Management	University of Tennessee	1956-60

EXPERIENCE

1972 to present — Senior Materials Licensing Engineer — U.S. Atomic Energy Commission, Washington, D.C.

Process license applications for uranium milling and uranium hexafluoride production facilities including preparing detailed statements of environmental impact of proposed or existing installations.

1968 to 1972 — Technical Superintendent — Union Carbide Corp., Vanadium Mine and Mill, Hot Springs, Arkansas

Supervised Technical Department Operations. Prepared budget. Established mill operating conditions for optimum recovery of vanadium from ore. Directed studies for solution of process problems, process improvement, and process development. Set up and directed air, water, and noise pollution control programs.

1962 to 1968 — Senior Development Engineer — Union Carbide Corp., Electronics Division, Parma, Ohio

Development and optimization of systems for production of pure hydrogen for use in fuel cells. Studies included catalytic steam reforming processes, thermal cracking of hydrocarbons, dissociation of ammonia, and hydrazine and hydrolysis

of metal hydrides. Planned and directed experimental work, correlated test data, prepared reports, and technical proposals for government contracts.

1960 to 1962	Chief Metallurgist	Union Carbide Corp. Uranium Mill Rifle, Colorado

Planned and supervised process studies directed toward improved quality and reduced costs in the production of uranium and vanadium compounds from carnotite ore. Responsibilities included supervision of air and water pollution control programs.

1952 to 1960	Senior Chemical Engineer	Union Carbide Nuclear Co. Gaseous Diffusion Plant Oak Ridge, Tennessee

Headed section engaged in engineering development studies directed toward improving various processes associated with the separation of uranium isotopes by gaseous diffusion. Process studies included fluorine generation, feed plant operations, byproduct recovery, barrier manufacture.

1951 to 1952	Lieutenant, USNR	United States Navy

Communications Officer USS Eldorado (AGC-11)

1946 to 1950	Chemical Engineer III	Tennessee Valley Authority Chemical Engineering Department Wilson Dam, Alabama

Pilot and production scale studies in support of production of phosphatic fertilizers, ammonia, nitric acid and ammonium nitrate. Included studies on control of stack emissions from phosphate and nitric acid plants.

1943 to 1946	Ensign, Lieutenant (JG) USNR	United States Navy
	Communications, Executive, Commanding Officer, USS LST 544.	
1941 to 1943	Junior Chemical Engineer	Tennessee Valley Authority Chemical Engineering Department Wilson Dam, Alabama
	Manufacture of water gas conversion and ammonia synthesis catalysts. Ammonia plant start-up.	
1941	Rodman - Chainman	Civil Aeronautics Administration New York, New York
	Airport layout and design	

PUBLICATIONS

"Hydrogen from Methanol for Fuel Cells" SAE, 1964.

"Miniature Hydrogen Generators" Power Sources Conference, 20th Annual Proceedings, 1966.

JAMES C. MALARO, JR.
4700 Broad Brook Dr.
Bethesda, Md. 20014
Telephone: 973-7718 (Work)
530-5472 (Home)

EDUCATION

1952-1956	College:	Yale University
	Major:	Chemical Engineering
	Degree:	B.E.
	Date of Graduation:	June 1956
1961-1962	One year of graduate study at the University of California (Berkeley) under a U.S. Atomic Energy Commission special fellowship in Health Physics.	

EXPERIENCE

June 1956-May 1959	Process Engineer U.S. Rubber Company, (Naugatuck Chemical Division, Naugatuck, Conn.)
May 1959-May 1961	In military service — served for nineteen months as Health Physicist for the U.S. Army Radioactive Material Disposal Facility (Edgewood, Md.).
Sept. 1962-Dec. 1966	Health Physicist U.S. Naval Research Laboratory.

Dec. 1966-Present

U.S. Atomic Energy Commission:

1. Senior Reviewer, Isotopes Branch, Division of Materials Licensing (Dec. 1966-May 1970).
2. Assistant Chief, Materials Branch, Division of Materials Licensing (May 1970 — March 1972).
3. Chief, Materials Branch, Directorate of Licensing (March 1972 — present).

PROFESSION SOCIETIES

Member of Health Physics Society (President, Baltimore — Washington Chapter) and American Nuclear Society.

Certified by the American Board of Health Physics.

CHARLES E. MACDONALD
Directorate of Licensing
U.S. Atomic Energy Commission
Washington, D.C. 20545

EDUCATION

B.S.	U.S. Merchant Marine Academy	1956

EXPERIENCE

1972 to date — Chief, Transportation Branch
Directorate of Licensing
U.S. Atomic Energy Commission

Supervises the review and processing of all types of license applications for and communications concerning the transportation and packaging or radioactive material.

1963 to 1972 — Materials Licensing Engineer
U.S. Atomic Energy Commission

Review and process for final action applications for and communications concerning licenses for receipt, possession, use and transfer of special nuclear material and source material with particular emphasis on those applications for packaging of radioactive material for transport.

1960 to 1963 — Supervisor, Health Physics, Combustion Engineering, Inc., Naval Reactors Division.

Established procedures covering personnel monitoring, waste disposal, environmental monitoring, building and area surveys for operation of the SIC prototype.

1958 to 1960	Radiological Safety, Combustion Engineering, Inc., Naval Reactors Division.
	Assisted in establishing procedures for the group.
1958 to 1958	Engineer, Combustion Engineering, Inc., Nuclear Division.
	Mechanical design of a PWR.
1956 to 1958	U.S. Navy

PUBLICATIONS

Implementation of the NEW AEC Transport Regulations 10 CFR 71, co-author, 1968.

LELAND C. ROUSE
USAEC, Bethesda, Md.
301/973-7457

EDUCATION

B.A.	Physical Sciences, Education	Nebr. State College at Wayne	1951

EXPERIENCE

1972 to present	Chief, Technical Support Branch	Fuels and Materials Directorate of Licensing

Responsible for administration and technical direction of Branch functions to provide technical support in connection with the AEC's licensing program for fuels and materials activities; primary efforts are concerned with the safety and environmental aspects of fuel fabrication plants and fuel reprocessing facilities. Prepare environmental statements for these type of facilities, and provide technical assistance in specialized areas in the safety evaluation of license applications. Assist in the development of related guides, standards and technical specifications.

1965 to 1972	Sr. Materials Licensing Engineer	Division of Materials Licensing, USAEC

Reviewed and evaluated for final action license applications for possession and use of source and special nuclear material. Major effort was concerned with evaluation of radiation safety aspects of fuel fabrication plants.

1963 to 1965	Radiation Specialist	Div. of Compliance Region IV, USAEC

Inspected and appraised the radiation safety programs of AEC licensees to determine status of compliance with AEC regulations and license conditions.

1960 to 1963	Specialist, Radiological Records	Hanford Atomic Products, General Electric Co.

Evaluated and directed Hanford radiation records program. Conducted studies to retrieve and use recorded date to detect trends in personnel exposure and protection practices; participated in conduct of personnel dosimetry programs at Hanford.

1956 to 1960 and 1952 to 1954	Specialist, Radiation Monitoring	Hanford Atomic Products General Electric Co.

Prescribed radiation control and protection requirements for operating personnel at reactors, hot cell facilities, plutonium processing facilities, radiochem research labs and during construction and maintenance operations. (Period from 1954 to 1956, U.S. Army).

1951 to 1952	Tech. Grad. Rotational Trainee	Hanford Atomic Products General Electric Co.

Accepted position with General Electric Co. at Hanford on rotational training program. Training assignments with production reactor operating group, process analytical chemistry section and a metallurgy research group were completed before accepting a permanent assignment in the Radiation Protection Operation.

SOCIETIES

Health Physics Society; alternate AEC member on ANSI N46 Nuclear Standards Committee (Design, Construction and Operation of Nuclear Fuel Cycle Facilities).

ROBERT J. DUBE
Technical Support Branch
Fuels and Materials

EDUCATION

B.S.	Physics	Bates College	1960
M.S.	Physics	U. of Delaware	1962
	Graduate courses in nuclear science and engineering.		
		Catholic U.	1968-1972

EXPERIENCE

1970 to date	Nuclear Process Engineer	Directorate of Licensing Fuel Fabrication Branch/ Technical Support Branch	
	Evaluation and analysis of the radiological safety and environmental protection aspects of license applications and environmental reports for fuel cycle plants, including principally fuel fabrication plants. Development of standards and guides.		
1964 to 1970	Health Physicist	Division of Materials Licensing Isotopes Branch	
	Technical evaluation of applications for Byproduct Material Licenses, including research, medical and industrial applications. Assisted in the development of standards and guides.		
1963 to 1964	Health Physics Trainee	Brookhaven National Laboratory	

A. THOMAS CLARK, JR.
6008 Beech Avenue
Bethesda, Maryland 20034
Telephone (301) 973-7427

EDUCATION

B.S.	Chemical Engineering	Rose-Hulman Institute	1958
Ph.D	Nuclear Engineering	University of Maryland	1972

EXPERIENCE

1971 to date	Chemical Engineer	U.S. AEC, Regulation Fuel Fabrication and Reprocessing Branch

Safety Evaluation of nuclear fuel cycle facilities. Review and development of safety standards and criteria for licensing of fuel cycle facilities.

1965 to 1971	Student	University of Maryland
1964 to 1965	Chemical Engineer	U.S. AEC, Regulation Irradiated Fuels Branch

Safety Evaluation of nuclear fuel cycle facilities. Review and development of safety standards and criteria for licensing of fuel cycle facilities.

1962 to 1964	Chemical Engineer	Savannah River Plant

Technical Assistance on fuel receipt and storage. Technical studies of reprocessing operations.

1958 to 1962	Chemical Engineer	Savannah River Laboratory

Development of processes and equipment for application to radiochemical separations plant.

PUBLICATIONS

A Cylindrical Transport Kernel in Heterogeneous Media.
Development of a 10-inch Centrifugal Contactor.

RICHARD B. CHITWOOD
USAEC, Bethesda, Md.

EDUCATION

BA	Chemistry, Physics & Mathematics	Adams State Alamos, Colo.	1952

EXPERIENCE

1968 to present	Chief, Fuel Fab. & Reprocessing	Fuels & Materials Div. Regulatory, USAEC

Responsible for the analysis and the evaluation of the radiological safety aspects of (1) fuel cycle fabrication and chemical processing plants including those which reprocess irradiated nuclear reactor fuels, (2) hot cell facilities used for research and development and testing of radioactive materials (3) licensing of operators for chemical reprocessing plants. During this period responsibilities have extended to the evaluation of packaging for shipment of large quantities of radioactive material and thermoelectric generators which use large quantities of radioactive material as a source of energy.

1962 to 1968	Inspection Specialist	Compliance Division USAEC

Responsible for conducting nuclear criticality safety inspections and developing the inspection program. Responsible for conducting nuclear criticality safety inspections at all licensed facilities, other than reactors in the United States, having sufficient fissile material to present a potential for accidental nuclear criticality. This included plants engaged in fuel fabrication, chemical conversion, and spent fuel reprocessing. Responsible for developing a program and selecting a staff for conducting such inspections in the expanding industry.

1955 to 1959	Process Engineer	General Electric Hanford Atomic Products Operation

Process engineer in chemical separation operations and plutonium and uranium production processes. From 1959 until acceptance of an appointment with AEC, responsible for establishing nuclear criticality safety limits and writing procedures for their implementation in a plutonium recovery and fabrication plant; also, was involved in the conduct of numerous "in-plant" neutron multiplication tests and was responsible for developing work on various radiation detection devices including a portable neutron spectrometer.

1952 to 1955		General Electric Hanford Atomic Products Operation

Involved in nuclear fuel development, fuel fabrication, reactor engineering, reactor operation and various processing activities associated with chemical reprocessing of spent reactor fuel.

KATHLEEN M. BLACK
USAEC, Bethesda, Maryland

EDUCATION

B.S.	Chemical Engineering	Massachusetts Institute of Technology	1950
M.Ch.E.	Chemical Engineering	New York University	1970
M.B.A.	Finance	New York University	1972

EXPERIENCE

1972 to present — Project Reviewer — USAEC, Directorate of Licensing, Fuels and Materials

On the staff of the Fuel Fabrication and Reprocessing Branch of Fuels and Materials. Participates in licensing of fuel cycle facilities for fuel fabrication and other types of facilities.

1968 to 1972 — Senior Nuclear Engineer — Parsons Jurden Corporation, a Subsidiary of the Ralph M. Parsons Company

Worked on various projects including quality assurance for an LMFBR conceptual design nuclear-process engineer for a mixed oxide fuel fabrication study; quality assurance consulting; fuel cycle economic studies.

1968 — Senior Physicist — Vitro Laboratories

Studies on nuclear systems.

1952 to 1968	Senior Nuclear Engineer	Parsons Jurden Corporation, Successor to Vitro Engineering Company

Nuclear and chemical engineer for a number of facilities including hot laboratories, fuel reprocessing, fuel fabrication pilot plant, deuterium recovery, nuclear power plant, research reactors.

PROFESSIONAL REGISTRATION

Registered Professional Engineer in New York.

MEMBERSHIP

American Institute of Chemical Engineers.

FRANK K. PITTMAN
U.S. Atomic Energy Commission
Washington, D.C. 20545
Telephone 301 973-4285

EDUCATION

B.E.	Chemical Engineering	Vanderbilt Univ.	1936
M.S.	Analytical Chemistry	Vanderbilt Univ.	1937
Ph.D.	Inorganic Chemistry	Mass. Inst. of Tech.	1941

EXPERIENCE

1971 to date — Director, Division of Waste Management and Transportation, U.S. Atomic Energy Commission.

Management of radioactive waste to protect the public and the environment.

1967 to 1971 — Director of Technical Services, Nuclear Division, Kerr-McGee Corp.

Headed all nuclear division technical activities.

1964 to 1967 — Special Assistant to the Corporate Vice President for Marketing, North American Aviation, Inc.

Primarily responsible for corporate activities in the technical and business planning and marketing efforts of the Company's nuclear programs.

1948 to 1964	U.S. Atomic Energy Commission. Various positions, including: Deputy Director, Division of Production, 1948-1954. Deputy Director, Div. of Civilian Applications, 1954-1957. Director, Div. of Industrial Relations, 1957-1958. Director, Div. of Reactor Development, 1958-1964.	
1944 to 1948	Los Alamos Scientific Laboratories. Various responsibilities in the processing, recovery and fabrication of plutonium for the Atomic Bomb Project, culminating in position of Manager of the Plutonium Production Site.	
1943 to 1944	Research Chemist	Cohart Refractories
1940 to 1943	Instructor of Chemistry	Mass. Inst. of Tech.

PUBLICATIONS

"Nuclear Power, U.S.A." with Zinn and Hogerton, McGraw-Hill, 1964.
Numerous classified technical papers on plutonium chemistry, 1944-1948.

HOMER LOWENBERG
USAEC, Bethesda, Maryland

EDUCATION

M.E.	Mechanical Engineer with Distinction in Chemical Engineering	Stevens Institute of Technology	1942
	Executive Development	Graduate School of Public and Business Administration, Cornell University	1965

HONORS

Tau Beta Pi	Honorary Engineering Society
Pi Delta Epsilon	Honorary Editorial Society

EXPERIENCE

1972 to present	Technical Assistant for Engineering	USAEC, Directorate of Licensing, Fuels and Materials

On the staff of the Deputy Director for Fuels and Materials. Participates in planning and management of fuel cycle facility licensing activities. Develops engineering criteria, guides, and standards for fuel cycle facilities including U mills, UF_6 Production Plants, fuel fabrication plants, fuel reprocessing plants, and waste disposal facilities.

1967 to 1972	Manager of Central Engineering	Nuclear Materials and Equipment Corporation, subsidiary of Atlantic Richfield Company

Responsible for planning, engineering and construction of all capital programs including new plant construction, facility modifications, equipment upgrading, future facility planning, and site selection for the nuclear program of this world-wide petroleum organization.

1948 to 1967 — Manager of Operations, New York — Vitro Engineering Company (Formerly The Kellex Corporation)

Responsible for the integrated activities of this architect-engineer-construction organization that handled many unique Government and Industry projects including over three dozen nuclear programs that covered a wide spectrum of applications involving nuclear power, nuclear fuel cycle processing, nuclear propulsion, and research and development.

PROFESSIONAL ACHIEVEMENTS

Professional Engineer in states of New York and Pennsylvania.
Engineering experience spans more than 30 years including 25 years of demonstrated performance in nuclear engineering. Responsible for the design and construction of more than 100 facilities including 40 nuclear projects valued at over $900 million.
Member of American Nuclear Society.

S. H. SMILEY
Deputy Director for Fuels and Materials
Directorate of Licensing
U. S. Atomic Energy Commission

EDUCATION

New York University (University Heights)
B.A. Chemistry 1941
M.S. Chemistry 1943

HONORS, AWARDS, AND FELLOWSHIPS

Phi Lambda Upsilon; Sigma XI (RESA)

Fellow: American Institute of Chemists

EXPERIENCE

Nov. 1971-Present Deputy Director for Fuels and Materials (formerly the Division of Materials Licensing), Directorate of Licensing.

Responsible for administering the AEC's licensing program for construction and operation of fuel cycle plants including uranium mills, UF_6 plants, uranium and plutonium processing and fabrication plants, fuel reprocessing plants and waste disposal facilities. Also responsible for authorizing the domestic use and export of byproduct source and special nuclear materials, licensing the packaging of radioactive materials for transport, inclusion of safeguards provisions in nuclear material licenses and the administration of the AEC's program for cooperation with the States. An important aspect of the work of the Fuels and Materials staff is the preparation of environmental statements.

1967-1971 Manager, Research and Development, NUMEC.

Reporting to the President, had responsibility for a broad range of activities covering the spectrum from basic research to pilot plant operations and developmental production operations, including corporate management responsibility for health, safety and licensing. Activities encompassed nuclear fuels process and equipment development on Pu, U and Th compounds.

Principal activities included:

—Nuclear fuels process and equipment development on plutonium, uranium and thorium compounds, covering laboratory, bench and pilot scale operations. Managed multimillion dollar LMFBR R&D program including successful prequalification effort for the FFTF.

—Inorganic chemistry development in such specialized areas as refractory coatings, plasma sythesis, spheroidizing, and sol-gel technology.

—A broad research and development effort associated with Atlantic Richfield's spent nuclear fuels reprocessing program.

—R&D including contract research and contract operations associated with uranium and plutonium scrap recovery.

—Metallurgical development, especially associated with nuclear fuels but including powder metallurgy and powder metal products development for the aircraft and aerospace industries.

—Irradiation processes and product development—synthesis by gamma irradiation.

—Technical support of development work in connection with thermal and thermionic devices, including the nuclear powered cardiac pacemaker.

—Operations analysis and planning associated with research and development activities, including relationship of R&D to the rest of the corporation.

—Responsibility for the Health and Safety and Licensing activities of the company, including dealing with the AEC and other outside agencies.

—Participation in corporate long-range planning.

1945-1967 Superintendent, Engineering Development, Gaseous Diffusion Plant, Union Carbide Corporation, Oak Ridge, Tennessee.

Specific major accomplishments at Oak Ridge include the following:

1. Initiated and directed all major programs associated with the development of continuous processes for uranium tetrafluoride and uranium hexafluoride manufacture at the Oak Ridge Gaseous Diffusion Plant (K-25). Had considerable contact with other AEC sites and commercial activities. Also directed a special research and development program on direct processing of ore concentrates to uranium hexafluoride.
2. Directed research and development associated with the conversion of uranium hexafluoride to uranium tetrafluoride, uranyl fluoride, and uranium dioxide by continuous, efficient processes.
3. Made important contributions to gas-solid contactor and flame reactor technologies. Specifically, was involved in developing the fluid bed as a reactor to convert the bed solid; also, along with colleagues, developed the stirred fluid bed as a chemical reactor. Holds the basic patent on the hydrogen-fluorine flame reactor for reduction of uranium hexafluoride.
4. Issued patent on flame reactor process to convert refractory metal or alloy powders with unusual properties.
5. Directed numerous other Oak Ridge programs; e.g., removal of trace impurities from uranium hexafluoride by sorption techniques; solvent extraction recovery of uranium; synthesis of inorganic fluorides, e.g., rhenium hexafluoride; tungsten hexafluoride; removal or uranium hexafluoride from a gas

stream by various techniques; boron isotope separation and boron production; chemical vapor deposition of tungsten, nickel. Established design criteria for construction of a Kel-F fluorinated plastics production plant; was responsible for management and program direction of a Kel-F fabrication development laboratory — here, some of the initial work on extrusion of tubing as well as transfer and injection molding was carried out.

6. Was a key member of the technical and management team that developed the uranium isotopes separation barrier — made significant technical and managerial contributions to programs associated with diffuser development and performance as well as those programs involving diffusion cascade auxiliary components, e.g., water recirculation systems, uranium hexafluoride trapping systems, fluorine and uranium hexafluoride disposal and recovery systems, etc.

7. Started and managed a major program on spent fuel reprocessing at K-25. The program also included development of a process to separate and to package radioactive krypton and xenon from fuel reprocesssing plant off-gases — using a freon solvent stripping and concentration system.

8. Initiated and managed a significant experimental and semi-production program, involving plasma torches and their use over a broad application base.

9. Authored numerous reports, many of which are on gaseous diffusion, particularly the separation membrane (barrier) and are classified. A few examples of unclassified publications dealing with uranium and fluorine technology are:

   a. Several chapters for the Pergamon Press Progress in *Nuclear Energy Series*, including an 87-page critical review, "Gas-Solids Reactors in Uranium Processing," *Progress in Nuclear Energy*, Series IV, Vol. 4, Technology, Engineering and Safety, 1961.

b. CEP Symposium Series, *Nuclear Engineering*, Part XV, "Nuclear Plant Experience with Fluidized Beds."

c. S. H. Smiley, D. C. Brater, C. C. Littlefield, and J. H. Pashley, "The Important Role of Elemental Fluorine in Uranium Processing Operations," Presented at the 1960 Fall Meeting of ACS, New York, New York, September 1960.

d. S. H. Smiley, D. C. Brater and H. L. Kaufman, "Preparation of Refractory Metal Powders with Unusual Properties," Journal of Metals (June 1965), presented at the National AIME Meeting, Chicago, Illinois, February 1965.

e. S. H. Smiley, "A Summary of Progress by Union Carbide Corporation, Nuclear Division, Oak Ridge Gaseous Diffusion Plant, Oak Ridge, Tennessee", Tungsten and Tungsten Alloy Tubing Development Meeting, Germantown AEC Headquarters, Washington, D. C., May 26, 1966.

f. S. H. Smiley, "The Future Use of Fluorine and Fluorides in the Nuclear Chemistry, Introductory Comments by the Chairman, presented at the 152nd National ACS Meeting, New York, September 1966.

g. "Flame Reduction of Volatile Inorganic Fluorides to Produce Pure Refractory Metal and Alloy Powders," presented at the Third International Symposium on Flourine Chemistry, August 30-September 2, 1965, Munich, Germany.

h. "Fluid-Bed Volatility Component, Engineering Feasibility, and Scale-Up Studies at the Oak Ridge Gaseous Diffusion Plant," presented at the XXXVI International Congress on Industrial Chemistry, September 1966, Brussels, Belgium.

1944-1945	Group Leader, Uranium and Fluorine Technology and Barrier Development, The Kellox Corporation; was involved in technical leader capacity for chemical processing projects, concentrating on UF_6 handling and analytical methods.
1943-1944	Research Chemist, Standard Varnish Works, Staten Island, New York; worked on resin and paint synthesis for improving of properties.
1941-1943	Graduate Assistant (Chemistry Department), New York University; taught undergraduate classes and assisted in undergraduate chemistry laboratories.

[72]

CHAIRMAN PAGLIN: Mr. Murray, you will have copies available for any interested participants?

MR. MURRAY: Mr. Chairman, unfortunately, among all of our other copying activities, we neglected to make a great deal of copies for other people. We have a few. Of course, they will be in the public record.

CHAIRMAN PAGLIN: I was going to say, Mr. Murray, should anyone have any questions about the qualifications of the experts appearing on behalf of the Staff, we can loan them our copies.

Thank you. We will proceed. Mr. Smiley.

Excuse me. If there is any difficulty in hearing the witness in the back of the room, please let us know and we will attempt to move the mike closer to him, or try to make it possible so everyone in the room can hear him. Is this PA system working? I get a nod of the heads from the back.

STATEMENT OF S. H. SMILEY, DEPUTY DIRECTOR FOR FUELS AND MATERIALS — DIRECTORATE OF LICENSING, REGULATORY STAFF OF THE ATOMIC ENERGY COMMISSION.

MR. SMILEY: The licensing review of individual nuclear power reactors is governed by 10 CFR Part 50 of the Commission's Regulations. The AEC's policies and procedures for implementing the National Environmental Policy Act of 1969 are set forth in Appendix D to Part 50. Appendix [73] D includes a requirement for a detailed environmental report from the applicant containing a cost-benefit analysis which should, to the fullest extent practicable, quantify and balance the various environmental, eco-

nomic, technical, and other factors involved in each proposed facility.

On November 15, 1972, the Atomic Energy Commission published for comment in the Federal Register a notice that it is considering possible amendments to Appendix D to deal specifically with how environmental effects associated with the uranium fuel cycle are to be considered in the cost-benefit analyses for individual light water-cooled nuclear power reactors.

The technical support for the amendments is contained in a document entitled, "Environmental Survey of the Nuclear Fuel Cycle." The survey sets forth the off-site environmental effects of the nuclear fuel cycle for today's reactors, which are uranium dioxide fueled and light water-cooled, and is prepared so that the fuel cycle environmental effects attributable to a single reactor can be evaluated. The survey covers the environmental effects of the various steps in the uranium fuel cycle which include uranium mining and milling, production of uranium hexafluoride, enrichment of the uranium in the isotope uranium-235, fabrication of reactor fuel elements, chemical processing of spent fuel to obtain reusable fuel material, management of radioactive wastes, [74] and transportation.

The following conditions were borne in mind in developing the premises for the survey:

(1) Each facility within the different components of the fuel cycle (except uranium mining which is under the jurisdiction of the U. S. Bureau of Mines) is or will be the subject of detailed AEC safety and environmental reviews in connection with the review of materials or facilities license applications or other federal actions. For example, a Safety Evaluation Report and an En-

vironmental Statement are prepared by the Regulatory Staff in connection with each application to construct and operate a spent fuel reprocessing facility. A safety review is then made by the Advisory Committee on Reactor Safeguards and the application is subject to hear.ngs before an Atomic Safety and Licensing Board.

(2) There are more than 150 nuclear power reactors in operation, under construction, or planned in the United States. Each uranium mining or milling operation, uranium hexafluoride production plant, isotope enrichment facility and fuel element fabrication plant will contribute fuel to a number of these reactors, but there does not appear to be any way to ascertain with certainty which fuel cycle facility will serve a given reactor or other licensed or nonlicensed (i.e., AEC operational) activity, like the isotope separation plant.

[75]

(3) There are a variety of ways of performing most of the steps in the nuclear fuel cycle.

In recognition of the above points, the following decisions were reached regarding the approach and content of the survey:

(1) The survey was based on a "model" 1,000 megawatt electrical light water-cooled power reactor using uranium dioxide fuel and having an estimated useful life of 30 years. The annual fuel requirement for this "model" reactor was taken to be an average of the amount required for the initial fuel loading plus 29 annual reloads. Recognizing that a typical boiling water reactor and a typical pressurized water reactor may have different annual fuel requirements, the amounts used in calculating the 30-year average were conservatively

taken to be the higher of the two alternatives for each year.

(2) Because for most steps of the fuel cycle a number of plants utilizing a variety of processes and operations are involved, a generic approach was used in assessing the environmental effects of the fuel cycle. For each step of the fuel cycle, a model facility was defined.

For those fuel cycle steps where a single method or type of facility predominates, this method or facility was adopted as the model. For other fuel cycle steps, again in the interests of conservatism, that mode of operation [76] imposing the most significant impact on the environment was in most cases adopted as the model. For certain steps, where only two or three facilities with widely different modes of operation and environmental impacts are involved, the model was based on a weighted averaging of the facilities' throughputs. The model facilities are thus not intended to represent particular plants. Rather, they were defined so as to be representative of the industry, with a conservative bias in assessing environmental impact. Effluent concentrations, radiation dose rates, and human population densities appropriate to the model fuel cycle facilities were then estimated using the best available data from existing or planned facilities.

(3) From a review of operations immediately "upstream" and "downstream" of each fuel cycle facility, only the generation of electrical energy for the isotope enrichment step was judged to cause significant environmental effects. The environmental effects of the coal fired power plants used in the grids supplying the power were therefore included in the survey. These coal fired plants are

the major source of gaseous effluents and use the bulk of the water for the entire fuel cycle.

(4) In each step of the fuel cycle the models were selected to be representative of the industry today with only minimal allowances for future technological advances [77] entailing lesser environmental impacts.

(5) The survey is not intended to relate to any specific site characteristics. Meteorology, hydrology, seismology, historical significance and site ecology are all analyzed in detail by the AEC in connection with its review of license applications for individual fuel cycle facilities.

(6) The survey does not attribute any benefits to the fuel cycle since benefits are credited to the generation of energy at the power plant which the fuel cycle supports.

(7) Occupational health and safety relating to on-site workers is not considered in this environmental survey or in environmental statements or reports. Such consideration is a major factor in the detailed safety reviews that are undertaken by the AEC Regulatory Staff as an integral part of the licensing reviews for individual fuel cycle facilities. Applicants are required to engineer, construct, and operate proposed facilities to limit the exposure of workers to fractions of prescribed low levels of radiation and potentially hazardous conditions. During the operation of the facilities, periodic checks by the AEC Regulatory Operations Staff are carried out to monitor the actual occupational conditions and assure that workers are not exposed to unsafe or hazardous conditions.

(8) Fuel cycles alternative to the uranium dioxide [78] cycle have not been considered since the light water re-

actors that are the subject of the proposed rulemaking are not at this time using any other form of fuel. In the future, some or all of these reactors may use uranium-plutonium mixed oxide fuel. At that time, we would expect that a similar generic survey would address the environmental effects associated with the use of that fuel.

Each component of the fuel cycle was analyzed for off-site environmental effects in a manner similar to the Commission's methods of assessing Environmental Impacts for Nuclear Power Plants, and encompassed: Natural resource uses including land, water, and fossil fuel; effluents including radiological, chemical, and thermal; accident considertions; and transportation of radiological materials.

The results of these analyses have been normalized to the annual fuel requirements of the model LWR and are summarized in Tables 3 and 3-A of the Environmental Survey. To place the resultant data in perspective, comparisons have been made with the environmental impacts caused by operations of comparable magnitude in other industries, and with the requirements laid down in various federal, state, and other regulations and standards.

The findings of the survey are summarized as follows:

Use of Resources

[79]

(1) Land

In meeting the annual fuel requirement for the model reactor, about 63 acres of land are temporarily withdrawn from active human use. The fencing required also restricts migration of large animals. Approximately 18 acres are transformed from their original state by the construction of facilities. This disturbed area is less than 10 percent of the equivalent annual commitment for coal mining for a 1000 MWE coal fired power plant. Less than five acres of

land are permanently committed to the production of the annual fuel requirement for the model reactor.

(2) Water

Approximately 11.3 billion gallons of water are moved in producing the annual fuel requirements for the model LWR. Eleven billion gallons of this is required to remove the waste heat from the coal fired power stations supplying electrical energy to the enrichment facility. Assuming once-through cooling at these power stations, all of this water is returned to surface water bodies. The remaining 338 million gallons is required for cooling, processing, and dewatering at other fuel cycle plants. The total of 11.3 billion gallons required for the entire nuclear fuel cycle represents less than 4 percent of the water requirement (approximately 300-400 billion gallons/year) of a 1000 megawatt electric light water reactor utilizing once-through [80]
cooling.

(3) Electricity

The total electrical requirements to meet the annual fuel requirement of the model reactor are 317 thousand megawatt-hours, which is less than 5 percent of the energy (seven million megawatt-hours) which the reactor would produce in a year's operation. Over 98 percent of the electrical energy required by the fuel cycle as a whole is utilized in the enrichment step.

(4) Natural gas

Approximately 100 million standard cubic feet (scf) of natural gas are consumed to produce process heat. Most of this is used in the milling operation. This quantity of natural gas could be used to generate roughly 10,000 megawatt-hours of electricity, which is less than 0.2 percent of the annual output of the model reactor.

Effluents

(1) Chemical

(a) Gaseous

Assuming that the electricity requirements of the fuel cycle facilities are supplies by coal fired power stations, the combustion products of coal would comprise nearly all of the airborne chemical effluents attributable to the nuclear fuel cycle. Since the uranium enrichment step consumes over 98 percent of the electrical energy required **[81]** by the fuel cycle, these gaseous effluents are ascribed to this step. To the extent that power is supplied by nuclear power plants, the total quantity of sulfur dioxide, nitrogen oxides, hydrocarbons, carbon monoxide, and airborne particulates would be greatly reduced.

Fluorine is introduced into the fuel cycle for the production of uranium hexafluoride and is removed from the fuel material in the fuel fabrication step. Fluorine thus becomes an airbore effluent from several steps of the nuclear fuel cycle. Although most of the fluorine gaseous wastes are effectively removed by scrubber treatment systems, approximately 0.7 metric ton is released to the environment as an airborne contaminant in supplying the annual fuel needs of the model reactor. To put this quantity into perspective, the estimated fluoride release from the total nuclear industry in 1980 assuming an installed nuclear generating capacity of 140,000 megawatts, electrical, would be less than 0.1 percent of the total fluoride released from four other basic industries: phosphates, aluminum, steel, and ceramics.

Measurements or calculations of airborne fluoride concentrations at the site boundaries of specific plants in the nuclear fuel cycle are well below the levels observed to have

an adverse effect on human health, and are well within the amounts permitted by existing state standards. State standards are used for comparison because there are no
[82]
applicable federal standards.

At uranium mills and uranium hexafluoride production plants, the combustion of natural gas for process heat releases nitrogen oxide to the environment. Dispersion calculations show that annual mean concentrations of nitrogen oxides from this source are within the 100 micrograms per cubic meter established as the limit in Environmental Protection Agency air quality standards. That standard is intended by EPA to protect the public from any known or anticipated adverse effects associated with the presence of oxides of nitrogen in ambient air.

CHAIRMAN PAGLIN: Mr. Smiley, may I just interrupt you for a minute. I apologize for the gentlemen standing in the back. I understand that chairs will be brought in very shortly, so if you will just bear with us, we will have enough chairs to go around.

Would you continue, please, Mr. Smiley.

MR. SMILEY: I have just completed discussing the gaseous chemical effluents. Now I would like to comment on the liquid effluents.

The largest quantity of liquid effluents, 240 thousand metric tons of waste solutions per annual fuel requirement of the model reactor, comes from the milling processes. This waste is discharged to the tailings pond, and since it does not normally contaminate unrestricted [83] ground or surface bodies of water, it does not actually become an effluent stream.

The concentrations of fluorides, nitrates, and ammonia contained in the liquid waste streams from fuel fabrication plants are a possible source of adverse environmental effect. Dilution of these constituents by the receiving body of water by factors ranging from 10 to 1000 may be required to achieve drinking water source quality. The dilution factor needed depends on the flow rate of the receiving body, its upstream quality and its downstream use. Efforts are in progress to minimize these releases from existing fabrication plants. Normally, sufficient dilution is easily achieved.

(c) Solid wastes, non-radiological.

The greatest bulk of solid wastes is generated in open pit uranium mining and milling operations. The barren rock and earth which, in open pit mining, must be removed to reach the minable ore constitutes a waste material only temporarily, since it is returned to the barren mine as backfill. The major source of solid waste in the uranium fuel cycle is the mill tailings, composed primarily of sandstone and clays. Some 91,000 metric tons of such wastes can be attributed to the annual fuel requirements of the model reactor. They are pumped as a slurry to the tailings pond, where they are permanently stored as solids in a chemical
[84]
form similar to their original condition, but containing slightly less radioactivity since uranium has been removed.

(2) Radiological

(a) Gaseous

The most significant gaseous radiological releases occur in the fuel reprocessing step. Nearly all of the krypton-85, most of the tritium, and minute quantities of radioiodine, other fission products, and transuranic particulates created

in the nuclear reactor fuel are released to the atmosphere from the reprocessing plant operations.

The annual 50-mile population dose from reprocessing operations attributable to the annual fuel requirements of the model reactor is estimated to be 4.4 man-rem, or about 0.005 percent of natural background radiation.

Small quantities of uranium and its daughters are released to the atmosphere in several steps of the fuel cycle. Measurements of radon presence in an open-pit mine revealed no significant alpha concentrations. The site boundary concentration of thorium-230 from the model mill producing the fuel requirements for about five model reactors is estimated to be approximately 15 percent of the amounts permitted by AEC regulations (10 CFR 20). In all other cases the concentrations of uranium and its daughters are estimated to range from 1-4 percent of the AEC limits for unrestricted areas.

[85]

(b) Liquid

In the fuel reprocessing for the model reactor's annual fuel requirement, approximately 2500 curies of tritium and 4 curries of ruthenium-106 are released in the liquid effluent from the model reprocessing plant. Because of the effect of dilution in receiving streams, measurements in 1971 indicated that the maximum off-site concentration of each species was less than 4 percent of the 10 CFR 20 limits.

Small quantities of uranium and its daughters are released in liquid effluents from each step of the fuel cycle. Estimates of the concentrations of radionuclides in effluent streams from fuel cycle plants indicate that concentrations are from 1 percent to below 10 percent of the 10 CFR 20 limits before dilution in receiving waters.

(c) Solid

The most significant solid radiological waste consists of the fission products separated from spent fuel in the reprocessing operation. These high-level wastes will be stored on-site for a maximum of 10 years, and will ultimately be shipped, probably by rail, to a federal storage facility. This federal facility will store and manage high-level solid wastes under constant surveillance for up to 100 years, or until such time as a more permanent federal repositary can be established. The storage facility will be designed to prevent the release of any radioactive material [86] to the environment by any credible environmental condition or human action. Dr. Frank Pittman, Director of the AEC Division of Waste Management and Transportation, will present further testimony regarding the AEC program for safe handling of high level waste.

Fuel element hulls and other fuel element parts contaminated with trace quantities of uranium, transuranics and fission products will be buried on-site at the reprocessing facility in a retrievable form. Other slightly radioactive material, such as laboratory wastes, may be buried on-site or at a commercial burial ground.

Wastes from uranium hexafluoride production facilities and fuel fabrication plants amount to a few curies per annual fuel requirement for the model reactor and are packaged and shipped by truck to a licensed commercial burial site. The geological and hydrological characteristics of these burial sites are such that there will be little or no migration of radioactive material from the site. The burial sites are enclosed by fences and access is controlled.

The solid waste tailings from the milling operations, which contain most of the uranium daughter products orig-

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inally in the ore, are pumped to the tailings retention pond and the activity is contained on-site.

(3) Thermal

Approximately 3.4 trillion Btu of waste heat are [87] discharged to the biosphere in fuel cycle steps meeting the model reactor's annual fuel requirements. About 95 percent of this comes from the isotope enrichment step. For purposes of comparison, the waste heat from the annual operation of the model reactor itself is approximately 50 trillion Btu. Thus, the thermal releases from the supporting fuel cycle constitute less than 7 percent of the thermal release from the model reactor.

Accident Considerations

The history of the nuclear fuel cycle to date indicates that accidents in fuel cycle facilities which could result in significant effects on the off-site environment are highly improbable. This record of the commercial nuclear fuel cycle industry has been accomplished by establishing safety as a controlling factor in all operations.

Each applicant is required in his license application to analyze potential conditions that could result in the release of radioactivity beyond the plant confines. He is further required, by proper design, construction and operation, which are carried out under quality assurance programs, to minimize the possibility of such releases. As a further assurance, the AEC makes a detailed independent safety evaluation of each commercial fuel cycle facility. This evaluation includes at least the following elements:

[88]

(1) *Site Analysis* — The geography, meteorology, hydrology, and other characteristics of the site are re-

viewed. In addition, severe natural phenomena pertinent to the site are taken into account in evaluating the design of plutonium and reprocessing plants.

(2) *Process Evaluation* — The process flow sheet is reviewed in detail to identify potential effluents and safety problems during normal and abnormal operations.

(3) *Structures, Systems, and Equipment* — The building itself, including significant features such as modules, layouts, corridors and points of access and egress, is reviewed for safety, emergency escape, limiting the spread of contamination and prevention and control of fires.

Ventilation, air cleaning, waste treatment, safety instrumentation and monitoring systems are analyzed for suitability under normal and abnormal conditions.

Process and utility equipment are reviewed for adequacy and reliability.

(4) *Safety Programs* — Among the safety programs reviewed are those involving contamination control, ventilation system performance, exposure assessment for workers and control of such exposure. Effluents and effluent treatment and monitoring systems for both liquid and gaseous streams leaving the plant are evaluated. Accident analyses that include consideration of criticality, radiation safety, [89] and nonradiation safety problems are performed. In plants handling special nuclear material, both liquid and solid systems are evaluated for criticality safety.

(5) *Procedures* — Each licensee is required to have detailed operating and maintenance procedures reinforced by quality assurance programs. The training and

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testing programs for operators are reviewed. Particular attention is given to fuel reprocessing plant operators, each of whom must be tested and licensed by the AEC. The licensee must have in being a hazard review committee or some similar organization that has responsibility for review of new processes and plant changes.

And I might mention these committees must meet regularly.

The licensee must also perform safety audits of operations and report the results to the AEC. License applicants must submit plans for coping with emergency situations. The AEC reviews these plans in detail. Emergency plans required for plants handling special nuclear material are spelled out in conditions attached to the license. Emergency plans required for fuel reprocessing plants are specified in Appendix E of 10 CFR 50.

(6) *Materials and Plant Protection Evaluation* — The AEC reviews in detail each applicant's program for safeguarding special nuclear material against theft, diversion, or [90] sabotage.

As a supplement to requirements for care in design, construction, and operations of nuclear fuel cycle facilities, each licensee is required to report to the cognizant AEC Regulatory Operations office any incidents which cause or threaten to cause unexpected events covered by AEC Regulations. The information in these reports is used as a basis for corrective action to prevent similar events from occurring in other plants and is taken into account in the licensing reviews on new or modified facilities of a similar nature. Such information is also evaluated to determine the need for new or modified standards.

The effectiveness of these measures is demonstrated by the fact that there have been no incidents in fuel cycle facilities using slightly enriched uranium in this country which have resulted in significant injury to or endangered the health of any individual in the general public. Nevertheless, for each fuel cycle facility requiring an AEC license, a series of potential accidents with environmental effects judged to range from trivial to serious is postulated and evaluated in the safety analysis performed before the individual facility license is issued.

Records to date indicate few, if any, of the routine type accidents involving special nuclear material have had any measurable effect on the environment. Thus, the review [91]
of accidents for this "Environmental Survey of the Nuclear Fuel Cycle" have been concentrated upon the most serious accidents that either have occurred or that can realistically be postulated. The estimated radiation exposures in unrestricted areas resulting from the most significant of these accidents are summarized in Table S-5 of the survey.

Transportation

Fuel material shipments are primarily made by truck. The probability of an accident occurring in truck transportation is small, varying from one in a million vehicle miles for minor occurrences to one in 100 million vehicle miles for severe accidents.

Fuel materials are packaged based on the nature of the contents. For example, material, such as yellow cake (U_3O_8) which has low radioactivity per unit weight is designed to retain the contents under normal handling since the potential exposure, even in a serious transportation accident, is relatively small. Packaging for fissile material such as uranium dioxide and enriched uranium hexafluoride

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is designed to retain the contents and prevent criticality in both normal transport and in severe transport accidents.

Due to the massive weights of the packaging required, future shipments of solidified high-level wastes are expected to be made by rail. The accident rate for rail [92] shipments is 0.8 per million car-miles. Solidified high-level wastes will be packaged in containers designed to withstand both normal transport and severe transport accidents without loss of contents or significant reduction in shielding.

The public will be exposed to a small amount of direct radiation exposure during the normal shipment of solid wastes. These dosages are estimated to be less than one ten-thousandth of one percent of the natural background radiation.

The report also contains an overview.

As has been discussed, the "Environmental Survey of the Nuclear Fuel Cycle" relates the environmental aspects of the nuclear fuel cycle to an individual model light water reactor. To provide additional perspective, an overview of the aggregate environmental effects from the total nuclear fuel cycle industry is presented for the years 1972 and 1980. For each of these years, industry demands, numbers of plants required for each step of the fuel cycle, and estimated individual plant capacities are given. The aggregate environmental impact of each step of the fuel cycle is then presented in a series of tables and accompanying text.

Our evaluation indicates that the environmental effects of the nuclear fuel cycle that are attributable to the model reactor are small. As stated in the Federal Register [93] Notice of Proposed Rulemaking (37 Fed Reg 24191), the

Commission is considering possible amendments to Appendix D to 10 CFR Part 50 of its regulations. These amendments would deal with the question of the account to be taken of the environmental effects associated with the uranium fuel cycle in individual cost-benefit analyses for light water-cooled nuclear power reactors. Two alternatives are proposed. The first is as follows:

In the case of light water-cooled nuclear power reactors, the applicant's environmental report and the Commission's detailed statement shall contain a full discussion of, inter alia, the environmental effects of the transportation of cold fuel to the reactor and irradiated fuel from the reactor to a fuel reprocessing plant and the transportation of low-level waste and high-level solid wastes (other than irradiated fuel) from the reactor to depositories.

Those documents need not cover the environmental effects of uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, disposal of low-level and high-level solid wastes or transportation related to such activities (other than transportation of cold fuel to, and irradiated fuel from, the reactor), since the environmental effects of those activities as related to a particular [94] light water-cooled nuclear power reactor have been analyzed in the Commission's "Environmental Survey of the Nuclear Fuel Cycle" and, if factored into the cost-benefit analysis, would be sufficiently small as not to affect significantly the resultant conclusion. The environmental effects of the latter activities will generally be considered in detail in proceedings in which approval for such activities, or closely related activities, is sought.

The second alternative proposed for consideration is the following:

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In the case of light water-cooled nuclear power reactors, the applicant's environmental report and the Commission's detailed statement shall contain a full discussion of, inter alia, the environmental effects of the transportation of cold fuel to the reactor and irradiated fuel from the reactor to a fuel reprocessing plant and the transportation of low-level wastes and high-level solid wastes (other than irradiated fuel) from the reactor to depositories. In such documents, the contribution of the environmental effects of uranium mining and milling, the production of uranium hexafluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation and disposal of wastes resulting from such reprocessing, disposal of low-level and high-level solid wastes and transportation related to such activities (other than transportation of cold **[95]** fuel to, and irradiated fuel from, the reactor), to the environmental costs of licensing the nuclear power reactor, shall be as set forth in the following Table S-3 of the Commission's "Environmental Survey of the Nuclear Fuel Cycle."

Mr. Chairman, this summarizes our evaluation of the environmental impact of the fuel cycle as it relates to individual light water reactors. We are motivated by the desire to present a full and frank discussion of the environmental costs attributable to the nuclear fuel cycle for light water-cooled nuclear power reactors.

We appreciate the opportunity to appear and to make this statement. We are prepared to answer any questions the Board may have.

[96]

CHAIRMAN PAGLIN: Thank you, Mr. Smiley. It is the Board's plan at present to have Dr. Pittman make his statement first before the Board addresses questions to the Staff.

Also again, I feel quite apologetic about the lack of sufficient seating arrangements. I am told again they should be here any minute. There are three chairs up front which have not been used.

Secondly, we are contemplating a break about 10:30 or at the time we finish with Dr. Pittman. At that time I would hope that the seating arrangements will be taken care of.

Mr. Murray, may we have Dr. Pittman's testimony now.

MR. MURRAY: Yes, Mr. Chairman.

STATEMENT OF DR. FRANK K. PITTMAN, DIRECTOR, DIVISION OF WASTE MANAGEMENT AND TRANSPORTATION, U. S. ATOMIC ENERGY COMMISSION.

DR. PITTMAN: Mr. Chairman, I am Frank K. Pittman, director of the Division of Waste Management and Transportation of the Atomic Energy Commission.

I appreciate this opportunity to testify on the high-level waste management phase of the important subject of the environmental effects of the uranium fuel cycle. The Division of Waste Management and Transportation (WMT) is broadly involved with this subject, since it has the responsibility for the development, construction and operation [97] of facilities for ultimate management of commercial high-level waste.

The disposal of high-level radioactive waste resulting from the chemical reprocessing of spent fuel from light water reactors is a much discussed problem faced by the nuclear power industry and the AEC. Some people feel that this is the most difficult problem associated with the effective use of nuclear energy to generate electrical energy

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and have even suggested that, until there is a demonstrated proven solution, a moratorium should be placed on further issuance of reactor operating licenses.

I would like here to state that there are available today proven methods for managing the high-level waste from the nuclear industry in a way which will assure first that man will not be adversely affected by the radioactivity either by external or internal contact with the waste itself, or by exposure to the penetrating radiation which it generates, and second, that the environment effects will be very small.

In addition to the methods based on proven technology, there are now in various stages of development — but not yet proven — several alternate management methods, any one of which appear to be capable of affording at least equal protection to man and the environment and at the same time to place less of an economic and manpower burden on future generations than do the methods proposed for near term use.

[98]

I will present some details of the current state of the AEC's preliminary engineering of a reference design for a facility to accomplish the safe management of the high-level radioactive waste from the commercial nuclear power industry. In addition, I will summarize the results of the preliminary analyses which we have made of the safety of this reference design, and I will discuss the scope of the effects which this management method may have on the environment.

I will also briefly touch on the status of our program for evaluation and development of as yet unproven alternates which offer promise of resulting in more efficient, and equally safe, management methods for use in the not too distant future.

In this way, I hope I will be able to allay what I feel are unwarranted fears in this area and show that the bugaboo of waste management cannot logically be used as a rationale for delays in the progress of an essential technology for meeting our growing power demands.

Before discussing the details of the management approach to be used by the AEC and to put into perspective the magnitude and timing of the problem, let me point out that under the Commission's regulations, as stated in 10 CFR 50 Appendix F, the first canisters of solidified high-level waste will probably not be shipped to the federal repository until 1983, and under the optimistic assumption on the rate of [99] growth of the nuclear industry used for current planning purposes, it will be well into the '90s before significant numbers of canisters of waste will be sent to the Commission for management of the repository.

To further bring perspective to the magnitude of the problem, the total number of reference sized waste canisters to be managed by the year 2010 is of the order of 80,000. The reference canister is one foot in diameter and 10 feet long and will hold approximately seven cubic feet of waste. Thus, the total volume of the high-level waste to be generated through the remainder of the century is of the order of 20,000 cubic yards which is equal to the volume of a one-story, 200 foot square building.

The Commission program for the Federal Repository. In recognition of the need to take timely technical and budgetary steps to assure that facilities are available to accept the commercial high-level waste to be initially delivered in the early '80s, the Commission, in the early spring of 1972, announced that it was proceeding on a program to design, construct and operate a surface (or near-surface) facility

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in which the solidified commercial high-level waste in sealed canisters will be stored. The facility and the canisters will be continuously monitored and maintained, and the canisters may be easily retrieved at any time if future technological development offers equally safe alternate [100] acceptable options having clear advantage over monitored maintained surface storage.

Since that time in 1972, engineering work on: (1) selection of the specific engineering procedures for receiving and handling sealed waste canisters; (2) heat removal, shielding, monitoring and maintenance of canisters and facilities; (3) conceptual design of facilities; (4) selection of site(s) for the facilities; (5) preliminary cost estimates; (6) preliminary analysis of safety under normal and abnormal conditions; and (7) operating and maintenance procedures, has proceeded with the objective that, while actual construction need not be initiated until 1979, all information needed to request Congressional authorization and initial funding for the first module of the repository will be available in time to allow the Commission, should it so desire, to include at least the initial phases of the project in its FY 1975 budget submission.

Now I would like to give some general considerations about the facility. Any facility used to manage safely the high-level radioactive waste generated by the nuclear power industry must provide that the waste be contained in a way to assure that the radioactive material will not migrate to the environment and that penetrating radiation generated by the waste will not impact on man.

Provision for containment and radiation shielding [101] for the relatively small volumes mentioned earlier would be easily achievable by simple containment were it not for the fact that radioactive decay releases significant quantities of

heat for significant time periods, for example, each one foot in diameter by 10 feet long canister may generate as much as 5 KW of heat at the time it is received at the repository. Five kilowatts of heat is 50 100-watt light bulbs, to give you a feel of the comparison. I would like to state this amount of heat generated is only at the initial receipt, after 10 years of cooling in the reprocessing basins, and that that amount of heat decreases with time. We have taken five as the maximum.

Should adequate provisions not be made to remove this heat and transfer it to the natural heat sink of the atmosphere, the waste and the canister would melt. Thus, the major factor in the design of the repository for high-level waste is the technique used to remove the heat from the waste.

The Commission has carried out extensive evaluations of safety, reliability, operability, maintainability and economics of various methods for removing heat, and has essentially narrowed the area for further study to techniques using either water or air as the heat transfer medium. Water has been selected as the medium to be used in the reference design, but continuing study and evaluation is being made for the use of air as the coolant.

[102]

Reference Design. In the reference design concept, the incoming shipping casks, each containing a number of sealed canisters — that number is considered generally to be about 12 for the 100 ton casks — and are removed from the rail car or truck — if it is the 100 ton cask, it will undoubtedly be shipped by rail and not by truck — the cask is removed from the transportation vehicle and transferred into a shielded receiving area.

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In this area, the shipping cask is opened and the waste canisters are removed for inspection and any necessary decontamination, repair, recanning or precooling.

Following any necessary pretreatment, the individual sealed waste canister is placed in a water-filled transfer cask and transported through a transfer corridor to a water-cooled storage basin.

Figure 1, which is available in the text that is in the record, shows the plan layout of the receiving cell and its relationship to the cask receiving area and transfer corridor. Figure 2 shows the elevation layout of the receiving cell.

When the transfer cask arrives at the storage cell, it is removed from its rail transporter and lowered with its contained canister into the water basin. The canister is removed, under water, from the cask and moved into its position in the water-cooled storage cell. See Figures 3 and 4.

[103]

The storage portion of the facility consists of a series of basin modules, each designed to hold 500 one foot in diameter by 10 feet long waste canisters. Each basin has its own cooling system where water is circulated by a pump through a heat exchanger immediate adjacent to the basin. External cooling water is circulated through this heat exchanger where it picks up the heat and is then sent to a cooling tower where the heat is transferred to the outside air. Figure 5 shows a schematic layout of the cell cooling system.

The total facility will be constructed in segments on a time schedule to meet deliveries from the reprocessors. Figure 6 shows the reference layout of the first segment which will contain eight 500-canister cells. Figure 7 shows how additional segments will be added in the future, and

Figure 8 shows the presently expected schedules for future deliveries.

Preliminary safety analysis. Detailed safety analyses must be based on the specifics of design and of actual site location which are not now available and will not be until a site is selected and Title I design has been completed. This latter cannot be accomplished until Congressional authorization and funding have been obtained.

Preliminary safety analyses have been made based on conceptual design and on the assumption that standards for protection against the forces of man and nature used for other [104] nuclear facilities such as reactors, reprocessing plants, et cetera, will apply.

A situation of considerable concern would be loss of ability to remove heat from the stored cans. This would result in melting of the canisters and waste and loss of some fraction of the isolation of the radioactive material from the environment.

The probability of this situation occurring is prevented by a combination of engineer features including, (a) redundancy of power supply and other essential cooling systems; (b) structural strength to withstand credible forces of nature — earthquake, tornado, et cetera; (c) combination of structural strength, plant security, et cetera, to withstand credible overt forces of man; (d) modular basin cell construction which limits the number of canisters subject to a single catastrophic event.

Thus, before a meltdown could occur, it would be necessary to have a series of failures of systems which will be engineered, constructed, and operated for maximum reliability under rigorous quality assurance programs before a situation could occur where sufficient water could not be

added to and maintained in the cell to keep it from leaking or boiling dry. The timing for such a series of failures to result in uncorrectable situations is important. The individual failure of power systems for circulating the coolant would not result [105] in pool water boiling for at least 16 hours. Various corrective actions may be taken any time within a week which would prevent cell water from boiling away. After the complete loss of water, namely after this week with nothing being done, an additional day would be required before the waste would begin to melt. The number of sequential failures required of highly reliable systems, combined with the long time periods available for repair and recovery from each, result in the judgment that this is an incredible incident.

Maximum credible accident. The maximum credible accident that can be conservatively postulated is assumed to take place during one of the various transfers of a single waste canister in air in the receiving cell. It is assumed that the canister is inadvertently dropped to the receiving cell floor. While the canisters are designed to be high integrity vessels and would probably not rupture, it is postulated for this analysis that it will rupture, and that its entire contents will be suspended in the air of the receiving cell. The cell air, containing this full load of waste material, then passes through two sets of HEPA filters. The effluent air from the filters is then assumed to contain 0.02 milligrams of waste per cubic meter of air discharged (Ref. ORNL-4451). Page P-852 is the reference page for the figure of the amount of air passing through the HEPA filters.

[106]

It is assumed that the waste is contained in one complete air change or 400 cubic meters of air. This is the volume of the cell area. Using the values of 0.02 mg/m^3 and 400 m^3,

a release to the environs of 0.008 grams of waste is postulated to have taken place. Dispersion calculations were made using a stack height of 28 meters, under stable conditions and a wind speed of 1 m/sec. This is a situation hwere inversions have taken place and where there is not any wide diffusion of the plume as it leaves the stack.

The resultant exposure calculations are summarized below:

	At inner exclusion Area fence, 0.2 mile (operator)	At outer exclusion Fence 0.7 mile (public)
Estimated first year bone dose	3.8 mrem	2.5 mrem

These estimated exposures for operators and the general public are 0.75 percent and 0.5 percent of the ICRP recommended maximum dose.

Radionuclide releases from "normal" operation. Releases to air. Under normal operating conditions, air releases will be minimal and produce air concentrations both on and off the site that are well below the recommended acceptable concentrations. The sources for occasional releases to the cell air would be material from (1) receipt [107] of contaminated casks; (2) decontamination of contaminated canisters; (3) repair or overpackaging of failed canisters that had some pinholes; and (4) miscellaneous clean-up operations around the storage basins.

Since all exhaust air will be filtered through two HEPA filters in series, these events are calculated to result in releases of radionuclides to the atmosphere in the range of 0.001 Ci/yr which is near the lower limit of detection. The maximum concentration of transuranics leaving the stack — before any dilution or diffusion has taken place — is cal-

culated to be 1.3 x 10^{-12} MCi/cc, while that of the fission products is 1.7 x 10^{-10} MCi/cc. For the public at the outer exclusion fence, dispersion, diffusion and dilution would reduce the estimated exposure to a very small fraction of the ICRP recommended maximum exposure.

We have made this calculation this way because the actual exposure at the fence site depends so much on the location and the kinds of windrose and meteorology that is assumed, so we thought it would be better to give the figures as it comes out of the stack, before any dilution has taken place.

Now there is another possibility of normal operation releases, and this is releases to the water. Since the water in each cell is isolated from that in other cells and from the outside coolant loop, no contaminated water leaves the
[108]
facility. However, it is assumed that there will be occasional releases of small amounts of radioactive materials from leaking canisters in underwater storage to the cell water. Such an event would be immediately detected by the coninuous monitoring system of the water in the basin. When such canister failure is detected by the basin monitor, procedures are put into effect to isolate the failed canister and remove it for repair or recanning.

In the meantime, the basin water is circulated through an ion exchange decontamination system. The contaminated resin is then managed in accordance with its level of radioactivity. If it is a very small amount of contamination, it can be handled as a low-level solid waste and buried in approved burial grounds, or if it is a fairly large amount of contamination that gets into the decontamination system, that would be canned and put back into the cell itself as a high-level waste.

The depth of cooling water above the canisters assures adequate shielding of operating personnel. Preliminary

safety analyses, on the basis of the design we are now using, indicate that the radiation level at the water surface would be less than 1 mr/hr.

General safety considerations. As I mentioned earlier, this facility, as well as all other facilities, must undergo a complete reivew. And full consideration will be [109] given in the facility design to such factors as protection against abnormal operating conditions or natural phenomena. The facility will be subjected to the similar standards and criteria and will be reviewed by similar procedures applied to the licensing of commercial facilities handling similar materials.

Environmental effects. To assess the environmental impact from a single 1000 MWE light water UO_2 fueled reactor, it is necessary to assess the total impact of the storage facility to handle the waste from the overall nuclear economy and then assign the unit reactor impact on the basis of the fraction of the total capacity which will be used by the waste from that unit.

Since essentially the main operational activity that will take place at the storage facility is the pumping of cooling water, the major commitment of resources is electricity and water during operation. The other impact is land area and construction materials used for construction of the facility.

For the purposes of estimating environmental effects, it is assumed that the facility will be built to receive and manage all waste generated through the year 2000 with the last deliveries to be made in 2010. A standard sized waste canister of one foot diameter by 10 foot long has been used in all calculations. Based on present predictions of the [110]

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growth of nuclear capacity for the remainder of the century, it has been calculated that a maximum of 80,000 canisters of waste, each generating a maximum of 3.25 KW of heat at the time of delivery will be in storage by the year 2010.

Earlier I said we were calculating on a maximum of five kilowatts, and I am using three and a quarter in this calculation. The reason I used three and a quarter here and five for the other statement, is the other statement was based on a mix before reactors, water reactors, gas-cooled, and toward the end of the period, fast breeder reactors, and the amount of heat per container for some of these others is what has accounted for the differences in my earlier statement. We are designing the facility to take up to five. In calculating the impact, though, I assumed that all of the canisters in the facility for this full period of time were water reactor fuel reprocessing canisters, so I could make this fractional statement that I have made here. The fraction of how much of the 80,000 is for the 1000 reactor one year cycle.

Using a waste volume of 2 cubic feet of solidified waste for each metric ton of fuel processed, the reference canister will hold the waste from approximately three metric tons of fuel reprocessed.

A 1000 MWE light water reactor operating at 30,000 MWD t/MT for 300 days a year will discharge approximately [111] 30 metric tons of fuel per year.

Therefore, the reference light water reactor fuel, when processed, will generate 10 canisters of waste per year. This gives a factor of 10/80,000 or 1.25×10^{-4} for the fraction of the total facility effect to be allocated to the single model reactor. Table 1 summarizes the estimates of the effects.

I think I will read these into the record, even though they are listed in the table.

(The document follows.)

Table I

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS FOR HIGH-LEVEL WASTE MANAGEMENT

	Full Facility	Per 1 yr. output of 1,000 MWE reactor
Land Use (acres)		
Temporarily Committee	~1000	~0.1
Permanently Committee	~100	~0.01
Water Use (millions of gallons) (1)		
Evaporated	~1000	~0.13
Cooling Tower Blowdown	~1000	~0.13
Electrical Energy (MWH/yr) (2)	~61 x 10^3	~7.7
Concrete (Cu. yds.)	~120,000	~15
Structural Steel (tons)	~8700	~1
Operating Effort (Manyears)	~200	≤1
Thermal Effluent (BTU x 10^9/yr)	~7000	~1
Solid Waste (Cu. Ft.)		
Nonradioactive	~200/day	~9
Radioactive	Max. 50/day	Max. 2

NOTES:

(1) Based on evaporation to remove heat plus an equal amount for blowdown.

(2) For pumping water.

[112]

I think these figures indicate that the effect on the environment of this facility itself is quite minimal. In the documents that is available, which I think has been passed out, there are some figures that show the layout, the present layout.

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CHAIRMAN PAGLIN: Excuse me, Dr. Pittman.

Mr. Murray, would you want to have these figures reproduced in the record at this point?

MR. MURRAY: Yes, Mr. Chairman, we would like to have these figures in the record. I might note in this regard that apparently 100 copies of Dr. Pittman's testimony, which contains these figures, sort of got mislaid. We understand it is over in the public documents room, at 1717 H Street, on the first floor, for anyone who is interested.

CHAIRMAN PAGLIN: Could you arrange to have them brought to this room?

MR. MURRAY: We will do our best to get them over here sometime today, yes, sir.

CHAIRMAN PAGLIN: Would you continue, please, Dr. Pittman.

DR. PITTMAN: Going on to the development of other concepts, at the time the Commission made its decision to use the concept of continuously monitored and maintained surface storage for management of the commercial high-level waste, a careful evaluation was made of the extent to which [113] research, development and testing work on other potential concepts for high-level waste management should be pursued.

The major current effort is to bring the bedded salt concept, about which so much is known, to the point of proven acceptability by the construction and operation of a pilot facility in a salt bed either in Canada or New Mexico at this time.

Work on this program is expected to reach a point where the Commission would be in a position, if it so desired, to request authorization and initial funding for the pilot facility in the FY 1977 budget submission.

In the pilot plant program about 500 to 1000 full-size sealed canisters of commercial high-level waste would be placed in the pilot facility under completely retrievable conditions. During the pilot plant operation, the canisters would be continuously monitored and any failed or failing canisters would be immediately removed. The facility would be highly instrumented so that the effects of heat and radiation on various parts of the salt bed and its surroundings could be determined and compared with the effects predicted from laboratory and field experimental work.

At the end of the pilot plant operation, and based on analysis and evaluation of data obtained therefrom a decision could be made as to whether disposal in bedded salt had, in fact, been proven safe, economic and acceptable. If [114] at the end of the pilot plant operation, or at any time during the course of such operation, use of bedded salt is contra-indicated, the emplaced canisters would be removed from the facility and transferred to the surface storage facility. If evaluation of the pilot plant operation indicated that the bedded salt disposal option is acceptable, the pilot plant could be converted to a full-scale operating facility, ready to accept future new commercial deliveries as well as the material already in surface storage. The possibility that the pilot plant could become an operating full-scale repository would be a factor in selection of the pilot plant site.

We are not selecting a site just for the pilot plant, but one that could be converted later on if information indicated it should.

In addition to the rather extensive program of research, development, testing, design, construction and pilot plant operation underway on the bedded salt concept, the Com-

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mission is currently making a thorough evaluation of all other potentially attractive near- and long-term disposal concepts in order to: (1) assure that no feasible concept has been overlooked; and (2) lay the groundwork for future program, should the work on bedded salt not result in acceptability of that concept for very long-term disposal. A final report of this evaluation will be issued in the summer of 1973.

[115]

Conclusion. In conclusion: (1) the program being followed by the industry under AEC regulation and by the AEC offers assurance that the commercial high-level waste will be managed safely from its initial production; (2) the surface storage method, to be used by the AEC, is good for as long as adequate human surveillance and maintenance effort is continued; (3) the probability that work currently underway will demonstrate the use of bedded salt as a safe, acceptable, ultimate disposal method within the next 10 to 15 years is very high; (4) should bedded salt not prove to be acceptable, other acceptable geologic disposal concepts offer reasonable probability of reaching a point of acceptability within two or three decades; and (5) the waste in initial storage will be easily retrievable for either near- or far-term disposal methods when they are developed.

In a word, we have a program which gives us maximum flexibility to meet our early commitments by the completely proven technology now available and at the same time, allows us to take full advantage of techniques which can relieve future generations of the surveillance and maintenance burden, should such techniques become acceptable as safe, permanent disposal methods.

(The documents follow.)

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ENGINEERED STORAGE FACILITY
CONTAINER RECEIVING AREA

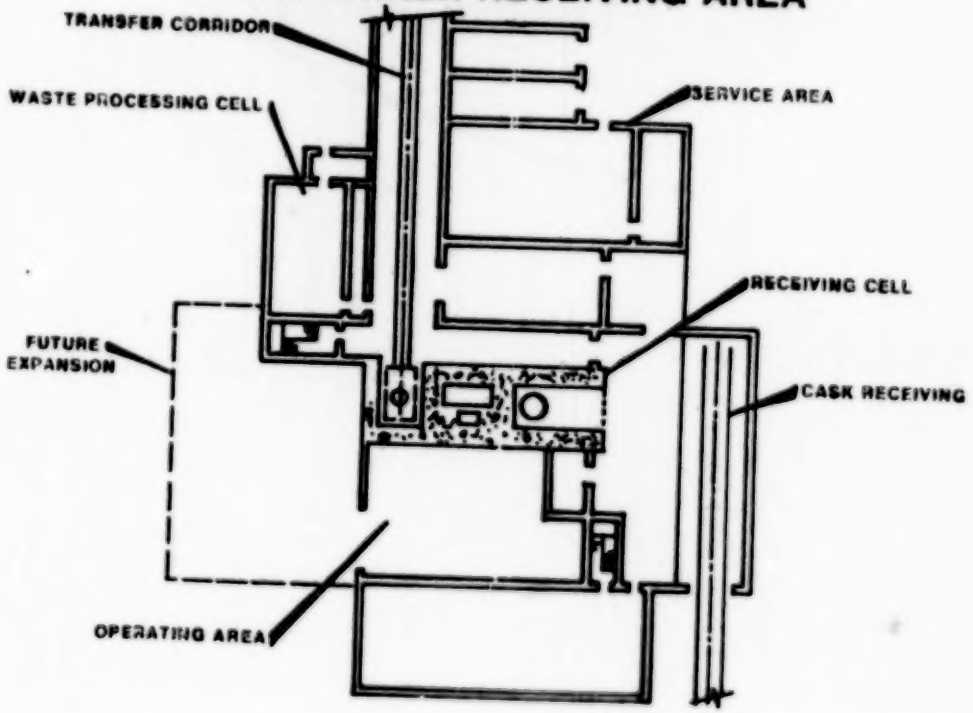

Figure 1

ENGINEERED STORAGE FACILITY
CONTAINER RECEIVING CELL

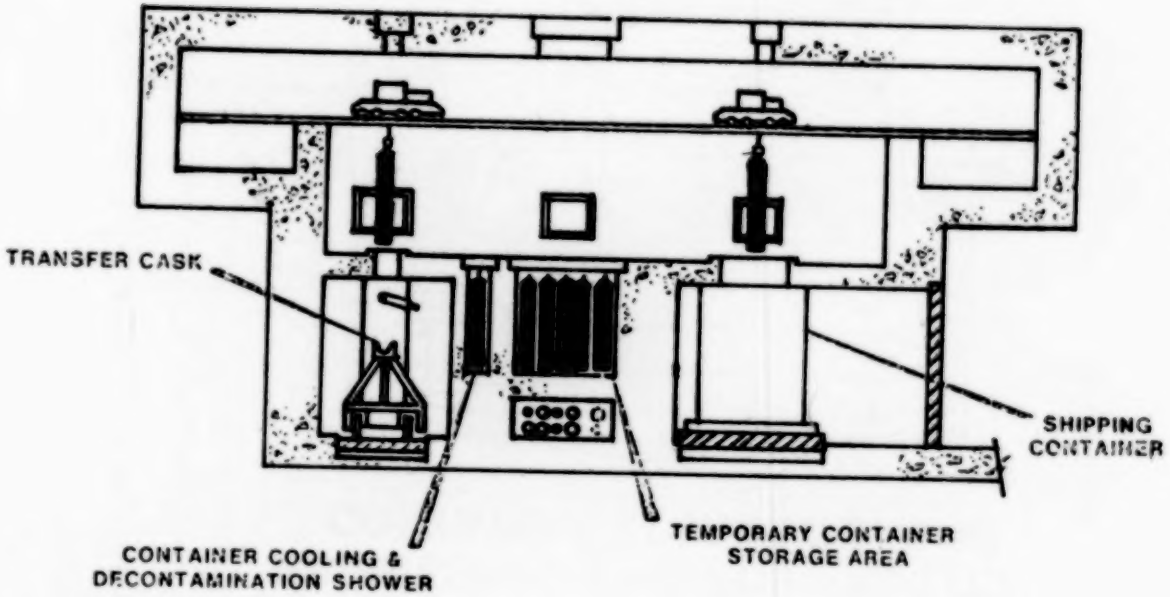

Figure 2

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ENGINEERED STORAGE FACILITY
CONTAINER STORAGE BASIN

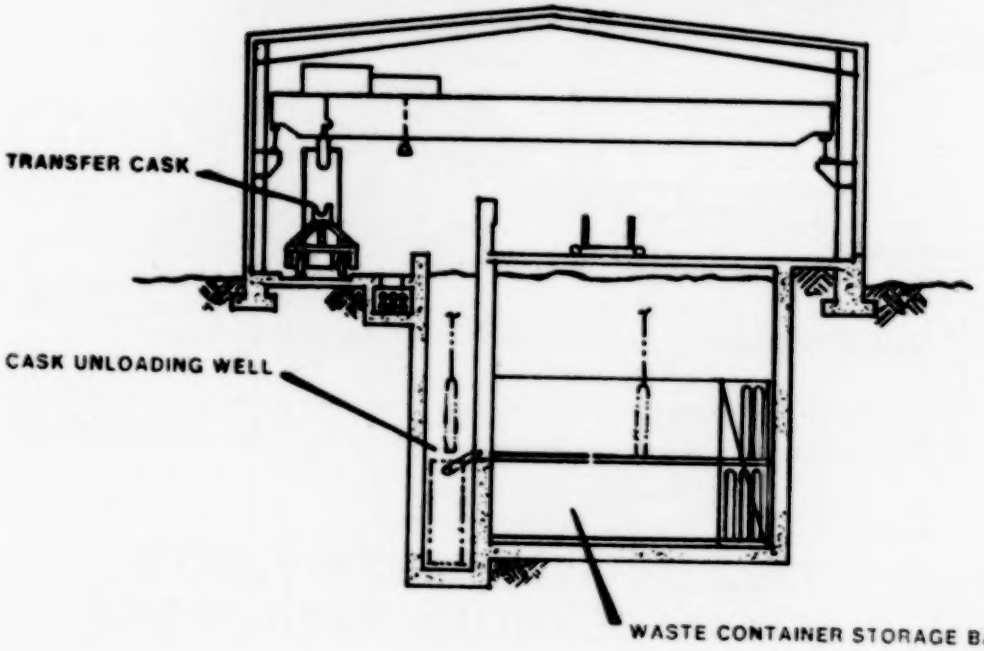

Figure 3

ENGINEERED STORAGE FACILITY
STORAGE BASIN PLAN

Figure 4

BLEED THROUGH

ENGINEERED STORAGE FACILITY SCHEMATIC FLOW DIAGRAM

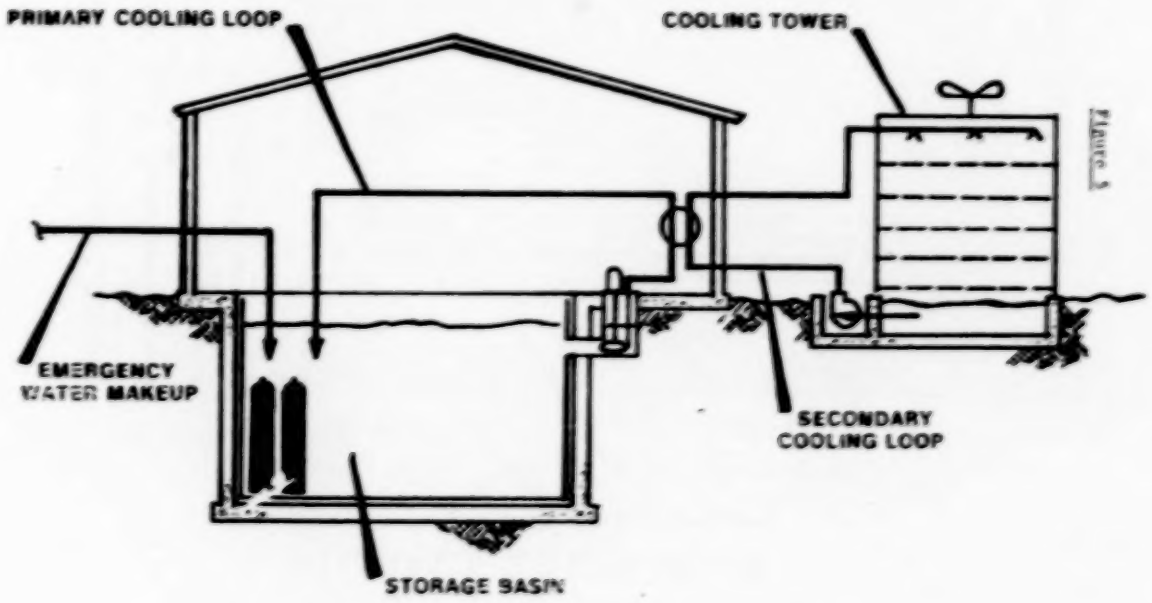

Figure 3

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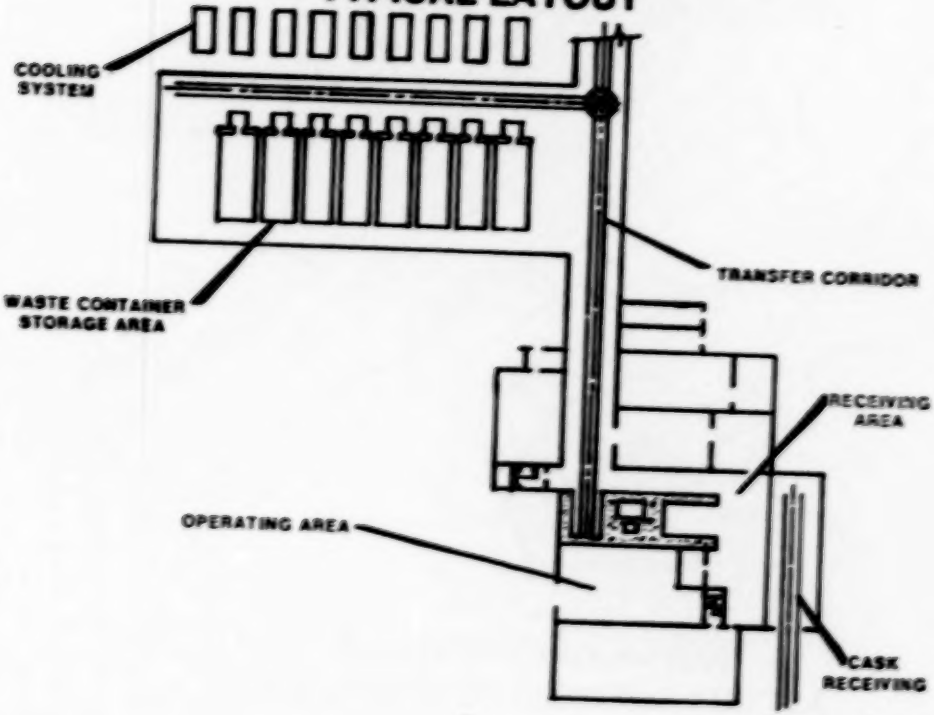
ENGINEERED STORAGE FACILITY
TYPICAL LAYOUT



ENGINEERED STORAGE FACILITY
SYSTEM EXPANSION

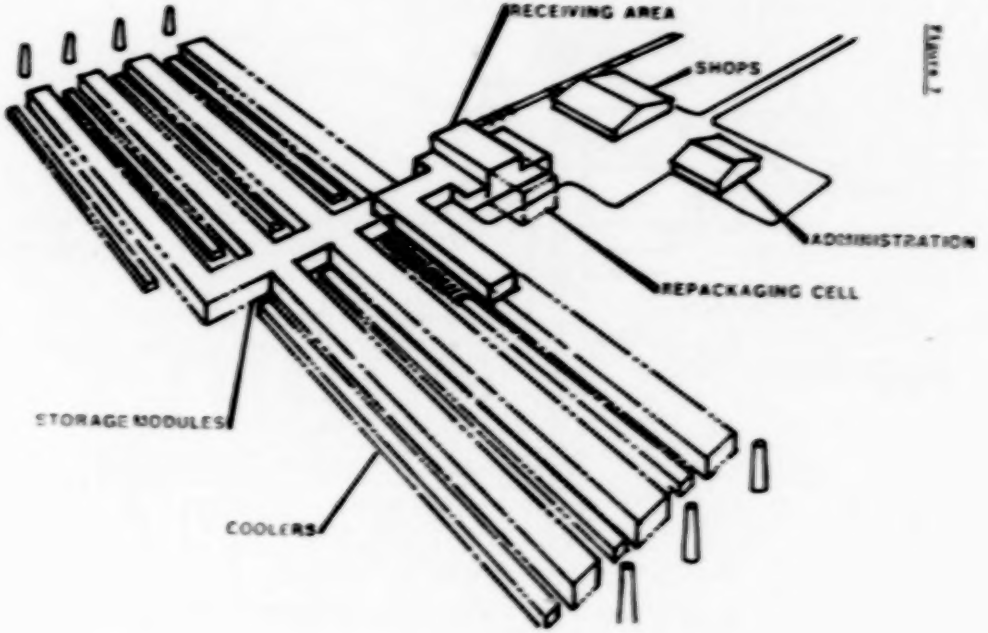


FIGURE 1

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BOOB COPY

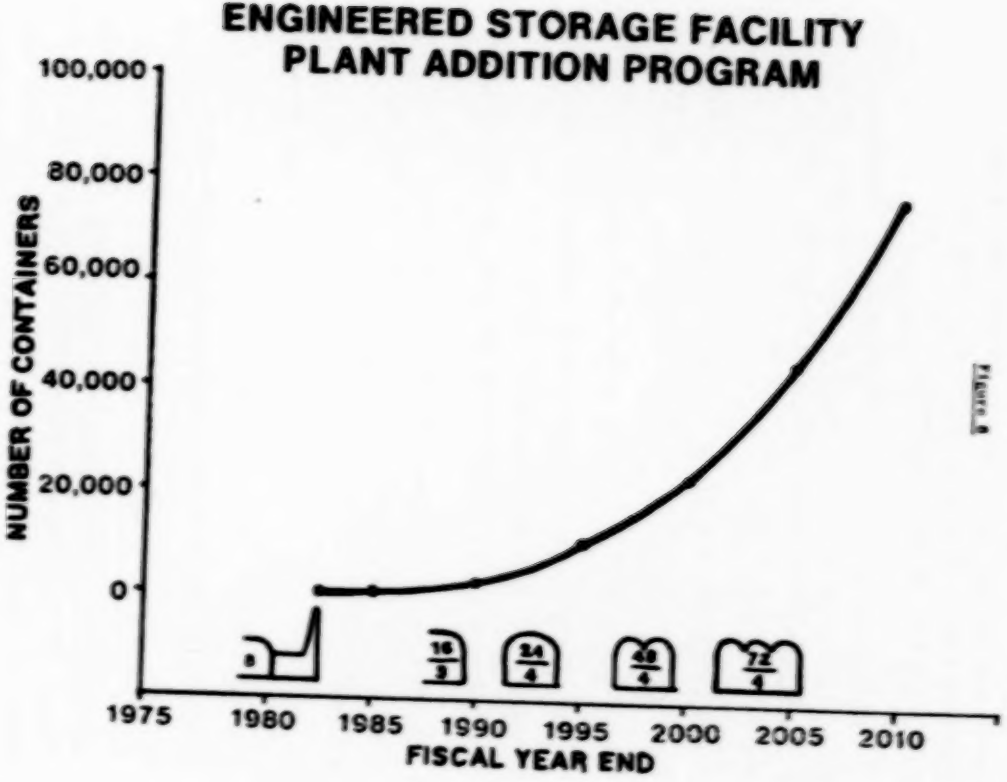
ENGINEERED STORAGE FACILITY
PLANT ADDITION PROGRAM
NUMBER OF CONTAINERS
100,000
80,000
60,000
40,000
20,000
0
8
16/3
24/4
48/4
72/4
1975
1980
1985
1990
1995
2000
2005
2010
FISCAL YEAR END

Figure 4

[116]

MR. MURRAY: Mr. Chairman, I believe there was a figure misread as a trillion, it should have been a billion. It makes some difference there. Dr. Pittman can clear that up. He is looking for it right now.

While he is doing that, I might add, so that the record is perfectly clear on this subject, that we gave copies of Dr. Pittman's testimony 48 hours in advance to the Board and every participant.

CHAIRMAN PAGLIN: Yes. Thank you. The 100 copies you referred to are for the people in the room.

MR. MURRAY: That is correct.

DR. PITTMAN: Where I said trillion in the thermal effluents, it should be billion in the table.

CHAIRMAN PAGLIN: Thank you, Dr. Pittman.

At this point it appears to be an appropriate time to take a 10-minute break and then we will return to questioning by the Board of the Regulatory Staff.

(Recess.)

CHAIRMAN PAGLIN: May we resume?

MR. MURRAY: Mr. Chairman?

CHAIRMAN PAGLIN: Mr. Murray.

MR. MURRAY: We are undertaking to send a messenger over to the public documents room to obtain extra copies of Dr. Pittman's testimony. I just got a bad rumor that we may not be able to find them over there, someone just came up [117] and whispered in my ear. We are not trying to hide Dr. Pittman's testimony, and we will do our best to get copies to everyone who wants a copy, even if it

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requires writing to me, James P. Murray, U.S. Atomic Energy Commission, Washington, D.C. 20545, I will guarantee a copy of that testimony.

CHAIRMAN PAGLIN: Thank you, Mr. Murray. I am sure that no one is trying to hide anything. This is a public hearing. All right.

DR. PITTMAN: I would like to say I hope not, because I made an awful lot of copies and I have an extra hundred at the AEC, plus a hundred that have been sent down here.

CHAIRMAN PAGLIN: We will see that they get here before the day is closed.

We would like now to proceed to questioning by the Board members of the Regulatory Staff. Thereafter we will then proceed with the presentation by the Environmental Protection Agency.

Again I would contemplate adjourning for lunch around 1:00 o'clock. That looks like the schedule right now.

Dr. Geyer.

DR. GEYER: In conducting the questioning, Dr. Steindler and I will switch back and forth. My questions in some cases have several parts. I think it will be the best [118] scheme to read through all of the parts, so you can see what the questions are being addressed to the problem involved. And then if you want to go back and repeat the parts of the question, I will be glad to do that. We have decided that about 45 minutes is the time available to us in view of the other people that wish to make statements this morning. The fact that we will not use more time than this will not necessarily mean that this is all of the questions we have. So we will be coming back from time to

time. And even then it may be that we are not covering in great detail all of the things that we might possibly ask questions about, but we will be dealing with things that seem important to us.

My first question has —

CHAIRMAN PAGLIN: Excuse me, Dr. Geyer. Mr. Murray has signaled he wants to make a statement.

MR. MURRAY: In that regard, Dr. Geyer, we would be pleased to try to respond to any additional questions that you feel you don't have time to ask at the conclusion of the prepared presentations, or in writing, or however the Board wishes.

DR. GEYER: Yes. We would anticipate this would be the case. Of course, the other statements may raise a good many of the problems that we might question on.

MR. MURRAY: Yes, sir.

DR. GEYER: The first question I have is o..? [119] just primarily for clarification. I think many people here know the situation, there may be some that don't, so I would like to ask what parts of the fuel cycle are under the recognizance of the Regulatory Staff of AEC.

MR. SMILEY: We start with uranium milling. Now in the environmental statement, because of the fact that now most of the plants that are being built are mine-mouth combinations, in other words, the mill and mine are associated, and this largely comes about because of the economics — I think it costs about five cents a ton mile to transport the ore. The mine is considered in the environmental statement in terms of the offsite effects. As you noticed, I covered in my testimony the overburden, we treated the overburden and any radon at the site perimeter.

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So the milling, in terms of the application itself, the safety analysis, the environmental report, and the mining as it relates to the milling, because the mine-mouth combination. Now we also cover the UF-6 manufacture.

There are commercial plants that manufacture uranium hexafluoride, so that is covered. The isotope enrichment is done by the Commission, and we do not cover that in our Regulatory licensing decisions. We cover the fuel fabrication and that would include the conversion of uranium hexafluoride to the uranium oxide, all of the steps involved therein. Some fabricators, for example, end up with [120] a uranium dioxide power, three particular fabricators, I think, go all of the way to the UO-2 pellets, and the final subassemblies. So we cover that.

We then cover fuel reprocessing, spent fuel reprocessing.

The other steps covered are waste management, because we have licensing responsibility for waste burial grounds, commercial waste burial grounds. Those that are not under agreement states, I might add. There are some commercial waste burial grounds under agreement states. There are also some uranium mills that are under agreement states.

We cover transportation of material between licensees. And in this regard, of course, we have very much in-depth reviews of containers, we have regulations spelling out our requirements. For example, in terms of a fuel reprocessing cask, we look to shielding, criticality, structural analysis, heat transfer, quality assurance.

I think that covers it.

DR. GEYER: Do you have sole responsibility for transportation?

MR. SMILEY: Transportation in the commercial sector, yes, sir. As far as the other transportation activities are concerned, under the Commission, this falls in Dr. Pittman's area. I guess we ought to mention that we have an interagency relationship with the Department of
[121]
Transportation, and we have a memorandum of understanding with them. For all practical purposes, we in the AEC do the reviews of the casks and the containers.

DR. GEYER: You do the regulatory work and the monitoring?

MR. SMILEY: Right. They are responsible once the carrier picks it up, right.

DR. GEYER: My next few questions will be related to matters discussed in the yellow book, the Environmental Survey, and I think it would be easier to give the page numbers and then ask the questions.

The first is on page S-13. This question has three parts and deals with the sentence under item 5 there at the bottom of the page. The first part of this question is how are environmental considerations "normalized"? The second part is, is it assumed that the environmental effect of multiple activities of a single kind is a simple multiple of the effect of a single activity of that kind? And under what conditions, if you make this assumption, would this prevail?

So the first is, how are the environmental considerations normalized, the term used here?

MR. SMILEY: I guess I would start by saying it is not easy to take an industry where for each step of the fuel cycle you have different flow sheets, and you also have
[122]
different size reactors. What we did was we recognized

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that reactors are built to various sizes, some reactors are smaller than a thousand megawatts mentioned, and others are larger. A thousand megawatts looked like a good number to use, because certainly if we take the environmental effects and we consider the total effects, and then assume that each reactor is a thousand megawatts in size, we will come very close to what will be the environmental effects associated with any one reactor that is up for licensing.

DR. GEYER: So the total effects of all reactors?

MR. SMILEY: Essentially what we said was this — yes — actually we were conservative. We essentially set the amount of fuel that would be required for an annual reload. I think the number came out to be 33 tons. And we said to produce that 33 tons of fuel, which actually is a little more than you would get for a 1,000-megawatt reactor, if you really do closely the balance between PWRs and BWRs, we took that 33 tons and said these are the effects from these 33 tons. You need to produce so much uranium at the mill, you have to make so much uranium hexafluoride, you have so much work at the diffusion plants, fabricate so much fuel, reprocess so much fuel. So all of the effects related to that, when we talk about land use, other natural resources, effluents, it was on the basis of that 33 tons.

Perhaps a better statement might have been we [123] normalized it to the 33 ton annual reload. But that is close to the requirements for the 33 thousand ton megawatt reactors.

Is that responsive to the question?

DR. GEYER: I think it is. There may not necessarily be a linear relationship between the effect of one plant and the effect of 10 plants, you know.

MR. SMILEY: That is correct. I think it is conservative this way, myself.

DR. GEYER: The way you have done it?

MR. SMILEY: The way we have done it, yes, sir. I might mention, Dr. Geyer, that each facility that we look at is licensed and evaluated on its own throughput. So what we have done here is quite apart from that. It is just an attempt to — okay.

DR. GEYER: The next question has to do with the table on page S-14, Table S-3, and as an example of how you arrived at the numbers in this table, what is the basis for the figure of 63 acres?

MR. SMILEY: Most of that comes from the milling. Again what we did is we took a site, I mean the model mill, for example, and we set that site — I think I have — we set that site on the basis of what we considered to be a reasonable model of the total industry.

Now we established a perimeter, we established how much land would be required for the buildings, how [124] much would be exclusion area. Again I think we took a conservative point of view. Then we said if one mill, for example, will turn out, as I recall it, an average size mill will do about five or six reloads, we said if you needed so many acres, let's say 300 or 400 acres for a total mill, a model mill, then an individual annual reload would take one-fifth or one-sixth of that, because of the fact the mill had the capability to turn out more than one annual reload.

DR. GEYER: In real life operations, how much variability would you expect to encounter in these figures?

MR. SMILEY: I think there would be a lot. And I think that we took a conservative point of view. For example, in

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the mine we used 3000 acres as the total exclusion area. So I think there are some that are smaller. But always the attempt was, and maybe this is a good time to make this point, the attempt was to try to put the maximum amount of impact, environmental impact, on the annual reload, if we could do it.

DR. GEYER: On that same table, but on the next page, the second line from the bottom, there is a statement that "no significant effluents to the environment" — what is the basis for this?

MR. SMILEY: Where are you, please, sir?

DR. GEYER: The same table, S-3, on page S-15, the second line from the bottom.

[125]

MR. SMILEY: Yes. I think I also stated that in my testimony, and that is the tailings that we referred to here, we are pumping tailings, including some of the liquid, over to these tailings ponds, which are designed to withstand natural forces and also to retain the tailings. Now because they are not completely impermeable, although after some period of operation, the slimes have a tendency to seal the fine pores of the tailings pond, normally it is not an effluent. It is not an effluent because the tailings, including the solution, are retained in the tailings pond and you lose the water, sometimes the water is repumped into the mill for reuse, and the rest of it is lost by evaporation.

Also there are other effects. Because of the fact that the water flows through soil, there are ion exchange effects, the radiation is essentially removed. So, for example, nothing or very little radium enters the flowing streams. There is a network, a radium network, I think they call it, and for the Colorado River basin, and measurements are made of radium in the flowing streams, and the values that

I have seen are very low, most less than one picocurie per liter. And this compares to a value of three for drinking water, and 30 in the AEC standards.

So there is a continuous monitoring network that the states are involved in, and this is where the data comes from. It is for this reason we reached the conclusion we state [126] in the report.

Mr. Murray just suggested that I say it is true, the land use for the tailings pond is already excluded in the 63 acres.

DR. GEYER: I presumed this was so. The record in the mining industry generally isn't all it might have been. Has a study been made of the ultimate fate of tailing ponds associated with milling and mining operations after they are abandoned?

MR. SMILEY: After they are abandoned? Let me say this, that this is not an easy question to answer. The AEC has control, as perhaps you know, over all of the operating mills and as a result of the NEPA, we now insist on arrangements for stabilization and long-term care of tailings.

For example, with the mill, the Humble mill that Humble Oil just built, we have a provision that there is a long-term care for 50 years after mill shut-down, and I think the mill will run, say, 15 years, so that is 65 years.

States are working on legislation for land reclamation. In terms of the mills that are shut down, these are the responsibility of the state, and of course the AEC has taken responsibility in this regard with respect to special problems, as I am sure you are aware of, in Grand Junction.

The mills that are shut down are not something AEC is looking at specifically. It is not within our jurisdiction. [127]

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But I must say we have an agreement state program, and we work very closely with the states, and we are insisting that the states look closely at the problem that you raise. There are three states, for example, I believe Wyoming, New Mexico and Utah, where about 88 percent of all of the uranium reserves are, states that are looking into land reclamation acts. And I suggest through this kind of action and through the radiation control programs of the directors of the various states, and through the obvious publicity of the mill tailings problems, we will see real progress in terms of care for abandoned mills. But they are the responsibility of the states right now.

I was just going to ask Don Nussbaumer if he would like to add anything to that.

MR. NUSSBAUMER: No, not at this time.

DR. GEYER: Thank you.

Now my next two questions are for information which if you don't have it right now, can be supplied later. But they are with respect to page B-13. I don't see where I have it marked on the page.

The question is, what is the quality of the water in these tailings ponds?

MR. SMILEY: It is quite acetic.

DR. GEYER: Do you have analyses you can supply?

MR. SMILEY: Yes, I am sure we do.

[128]

DR. GEYER: The same question might be asked also about what is the quality of the water pumped from the mines?

MR. SMILEY: Well, the mines also put up ponds, and I must say the primary motivation initially is to recover

the slimes, because that is pretty good ore. But the water is also dammed and ponded from the mines. This is the drawdown you are talking about?

DR. GEYER: Yes.

MR. SMILEY: Right. And it is allowed to find its way down washes and draws to various flowing streams. And again the radium quality of the water in the Colorado River basin, which covers a very large area, is a fairly good testimonial to the quality of the water from the mines.

DR. GEYER: If you have data on that, I would like you to supply it.

MR. SMILEY: Yes, sir.

DR. GEYER: The next question has to do with the last sentence on B-20. It would be useful if you could supply additional information on what is meant by the word "excessive" and what you have in mind with regard to the treatment. These are very general terms that don't tell you much. You need not supply this now.

MR. SMILEY: Fine. We would be glad to do that, sir.

DR. GEYER: I think I have been going long enough.

[129]

Dr. Steindler?

MR. SMILEY: Excuse me. I could make one piece of information available now. As far as we know, the one thing we should mention is that this industry, unlike maybe the nuclear power industry, has been going on for some time, because of the military requirements in the '40s, so we have about 30 years of experience. Our information is that the AEC Region Four, I believe the Denver office, it is the compliance office, reports only one case of contamination of surface waters by radionuclides, and this occurred

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— I don't think it adds much to say it agreed in an agreement state, where we don't have a responsibility, but that is a fact. However, we work closely with the agreement states on these problems.

[130]

DR. STEINDLER: Let me make a comment, to begin with. I think part of the problem, if there is a problem with the environmental survey as issued, is the title. The survey title is "A Survey of the Nuclear Fuel Cycle," and I think part of the channeling of the contents of the document obviously is going to deal with this unique classification.

But before we get into that, let me make another quick st tement, that my questions are likely to be generic. That is . don't think we have time at this point to delve into the problems, the potential problems with the numbers and specifics. Let me bring a couple of things out. First of all, is it correct that this is in effect a draft document to be ultimately perhaps revised in response to questions and comments on the additional testimony which may raise questions or challenge particular aspects?

MR. SMILEY: Well, certainly we sent it out for comment and we were very serious, so we will want to see what comments back in, as you suggest. Also the testimony at this hearing. And then make a judgment as to what we ought to do. We can do anything, I guess, from errata sheets to a rewrite. I don't think we rule out that latter possibility.

DR. STEINDLER: I think it is perhaps pertinent at this point also to have some discussion as to the rationale or the role of the exclusion of plutonium as a **[131]** fuel cycle participant, and then subsequently I think we could get into the question of how come we are fairly silent on

plutonium as a product from a reprocessing plant. Initially perhaps you could give us some rationale for why plutonium was excluded as a participant in the fuel cycle, and where you see it coming into play, either subsequently or what are the plans? If you could address yourself to that question and follow that up, perhaps, with a similar comment on HTGR and the uranium thorium fuel cycle.

MR. SMILEY: First, let's take plutonium. There is no question that we will handle mixed oxide fuels sometime in the future in a similar analysis. Right now reloads are strictly uranium dioxide. And the plants producing plutonium, as a matter of fact, mixed oxide fuel, are rather small. Mainly those people who are involved with plutonium, say 95 or more percent of plutonium being handled today, is handled for the fast breeder reactor program.

We might be talking about 1000 kilograms of plutonium altogether, two contractors handle the major amount of that, practically all of it. So we don't have a viable reload industry today.

Now, secondly we wanted to get this document out and have it truly represent what is going on today. So indeed we addressed it to the UO_2 fuel. I could tell you more about the rationale, but is it sufficient to say that we [132] definitely plan to put one out on the mixed oxide fuel and it is not the first one on our list, the first follow on, it would be probably the next.

By this time, I think we will have a lot more information about the whole mixed oxide fuel cycle. As I say, the plants are small today, fabrication plants: even data on reprocessing is such that the existing reprocessing plants can't fit the flow sheets immediately to the plutonium fuel reprocessing. So there are things we still have to learn. This is

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not to say, incidentally, that when we license a plant for handling plutonium for mixed oxide fuel, we don't do a thorough study of that plant. In fact, plutonium plants get special loving care because of the fact that it is a hazardous material, and to the extent that we look at natural phenomena, like we do for reprocessing plants and reactors. Now the HTGR, we have started on that, you are absolutely right, this is something we have to do.

I would expect that at some time within the next six to eight months, we will have a similar document on the HTGR. The problems are somewhat different, as I know you know, and we have to deal with uranium-233, parts per million of U-232 in it, which has long lived very hard gammas. That is in fabrication. We have to deal with a thorium flow sheet, with high enriched uranium-235. We [133] expect to have something on this which will approximate this document you have seen on the HTGR in about six to eight months. The one part of the flow sheet that we will have to go on the basis of research data and development data is, of course, the reprocessing, because there is no reprocessing plants for HTGR now and the fuel, as I understand it, is being stored in Idaho.

Does that answer your question?

DR. STEINDLER: Yes, but let me get back to the question of plutonium and the reprocessing plants as a product. There were a couple of points there. Perhaps this might be a good time to touch on those. I think a careful reading of this document makes it reasonably obvious that the silence, the apparent silence on one of the major products of the reprocessing plants is outstanding, and specifically I am talking about plutonium.

What is the current attitude of the staff in relation to the whole question of plutonium, plutonium load-out, plutonium

storage, particularly since apparently the plutonium that is going to be coming out of reprocessing plants is going to have to be stored, if in fact the industry is not yet ready to go into plutonium loadings? Where and how would you estimate that this kind of thing should be treated, if you worry about the fuel cycle as it currently stands here? **[134]**

MR. SMILEY: Well, you are right about the silence on plutonium, except, of course, we did note that storage was the one issue we talked about. The reason is because the light water reactor fuel cycle ends with storage of plutonium and for those who are not aware, I would like to make that clear; I know you are aware of that. The fact of the matter is when you reprocess UO_2 fuel, you end up with plutonium, and until there is a use for it, it will be stored.

Now if you are asking about the technological questions involved, storage of plutonium, certainly we feel is within conventional engineers' wisdom, and storage facilities are available, others can be built. The responsibility will be the industry's to store plutonium until such time as they convert it to other forms for reuse. Storage containers can be designed safely. And certainly can be put into a structure just like a reprocessing plant or other plutonium facilities, where we don't have concern about such things as natural phenomena. That is all one would think he would have to treat, I would suppose, in terms of plutonium, until such time as it is shipped out. In actual fact, I think you are right, and I think the next one we will do after HTGR will be the mixed oxide fuel. So the practical aspect will be that there will be storage for plutonium, maybe more than people are now allowing, but **[135]** eventually the stuff will be shipped out.

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DR. STEINDLER: I am trying to draw the distinction between plutonium as it is converted into fuel, used in LWRs, and plutonium as a product of a reprocessing plant today, or whenever the plant cranks up.

MR. SMILEY: You mean for use in the fast breeder or something?

DR. STEINDLER: No, plutonium as it comes out of LWR irradiated fuel. Since it is a product, it has to be handled. So you have a load-out area which produces whatever their rate is.

MR. SMILEY: I see. Well, in a sense we have —

DR. STEINDLER: Let me comment. That is precisely the impact, the impact of that kind of operation, which may seem small in terms of tonnage, but is not necessarily small in terms of risk, that it seems to me might well be part of a revised or addition to this document.

MR. SMILEY: We could look at that. My feeling is we have sort of treated it, and the reason I feel that is the everything in — when that plutonium is handled, until it is loaded out, it is behind five feet of concrete. So we have certainly treated it in effluents. I should make that clear. When we look at the effluents from the reprocessing plant, plutonium is a radionuclide that is considered. So that extent, in terms of gaseous effluents, we have treated it. [136] Liquid effluents, we are storing on site. So essentially that is treated, too. I mean it is not a product that goes to the environment. In terms of accidents, we have treated a critical accident in the reprocessing plant as part of the survey, so in a sense we have addressed ourselves to that. And the load-out is included in the reprocessing plant effects. It might have been a little more substantial, and perhaps can be clarified.

DR. STEINDLER: That is in effect what I am suggesting. Let me ask one more question on this. Because the reprocessing plant must handle plutonium, the reprocessing plant would surely generate low beta gamma wastes, which are plutonium contaminated, be it equipment or whatever. The disposal of that material is subject to, it seems to me, some kind of an environmental analysis.

I am wondering whether it wouldn't be worthwhile detailing what the Commission's current approach is to the storage, retrievable or otherwise, of that kind of waste, and I am laboring under the impression that there are some regulations which have been promulgated by the Commission to deal with contractors' approach to that problem, and it might well be of interest to at least comment on that.

MR. SMILEY: You mean the contractors' approach to handling low-level waste?

DR. STEINDLER: Yes, and the segregation question.

[137]

MR. SMILEY: I would be pleased to make a comment on that.

First, it is really fair to say there is very, very little, if any, low-level waste that leaves the plant, transuranic wastes that leaves the reprocessing plant, practically all of the low-level waste, and this is in the thousands and hundreds of thousands and later millions of cubic feet of low-level waste, will come from the fabricators. When we look at the plutonium cycle on reload, that will be an important part of the elevation. So you can look for that in that part of the survey. Now it is true that the Atomic Energy Commission contractors, those who have facilities available, are now being asked, I believe it has been for a couple of years, and Dr. Pittman can add something to this, maybe, they are being asked to store the low-level wastes

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on site. It is true also, and I think fair to say some contractors, like Argonne National Laboratory, for example, ship low-level waste to commercial waste burial grounds still, because they don't have available facilities on site. We presently are allowing our people — I am now talking essentially outside of this survey, but I think you have asked a question a lot of people are wondering about — we are now allowing our people to ship low-level alpha waste, transuranic wastes, to commercial waste burial grounds. I think it is also fair to say we are looking at the [138] question very seriously, looking at what the options are, just as the general manager of the Commission has done, such things as retrievability, having alpha wastes stored that is retrievable in storage facilities, defining what a cut-off point might be where one might allow plutonium wastes down in some very, very low-level, to go to commercial waste burial grounds.

So that is a very serious problem for us to look at. And even more so, now, because of the build-up of plutonium. One other thing might be of interest to you. We are encouraging industry to minimize the amount of low-level waste that they generate, right from the design stage, and I commented on this to industry in September at a meeting of the industrial people. Also we are looking at ways of, through Dr. Pittman's organization, of how to handle low-level wastes, incineration of leaching, this kind of thing. The combination of these approaches, plus our very strong desire to minimize the amount of low-level waste that we have to deal with, I think will see new policy decisions in the near future.

DR. STEINDLER: Our time schedule is going to run out, so I was trying to find out how flexible it really is. As a generic comment, one of the, I think, outstanding practices of the Staff has been in the past, at least as far as I can

tell, to meticulously document the assumptions that [139] are made in the discussions. I find that that has not been done here and as a consequence leads to some of the kinds of questions that I think Dr. Geyer was asking and could lead to a rather long engagement between us on how you got this and where you got that. I guess I must assume that one of the reasons that those assumptions have not been documented and clarified or justified in the purest sense of the word, is because of the time schedule required to get this thing on so we could get to hearings. Can it be assumed that if there is going to be a significant revision to this document that in those areas where assumptions are made, particularly where there is a statement to the effect that something is trivial, or insignificant, that somewhere there will appear in that same document some kind of justification based on data or a reference which one can go back to and find the source.

If that is a reasonable assumption, then I can, you know, move on from my present set of questions. If not, then I have to poke around a bit more.

MR. SMILEY: Well, we supplied references, obviously, to put as much as we could into the references so one could go back and see how we did the work. I would say that the goal of the Staff was to take every one of those comments and to say how we got the information. I certainly feel that it is in order to go back and look at it [140] once again, because sometimes what might be obvious to us is not obvious. So we will do the best job we can on that. I appreciate your raising the point.

DR. STEINDLER: I am simply suggesting it is probably worthwhile to be sensitive to what may seem like nit-

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picking, but really represents perhaps a serious question as to how you got from A to B.

MR. SMILEY: You don't want the survey to include all of the information? You mean the references themselves?

DR. STEINDLER: I think references are perfectly adequate. I am personally used to reading documents which, if they make a statement that could be subject to some kind of inter-presentation, having some reference attached, so I can go back to see what the basis was.

MR. SMILEY: We will make every effort to go back and see if we can improve that.

DR. STEINDLER: There is another question that arose regarding the magnitude of the liquid effluents. The standards of comparison in this document seem to be in general. Following dilution by whatever appropriate body of water we put our effluents into. And while I am not an expert on current regulations, I got the impression in talking to people, that at the moment concentrations are being thought about in terms of as they are discharged, rather than as diluted.

[14]

MR. SMILEY: Yes.

DR. STEINDLER: If you were to use the as-discharged criteria in all of the whole rather substantial mass of data, do you foresee that the conclusions that you have reached in general would be significantly changed, and if so, where?

MR. SMILEY: Well, you may not be an expert, but I think you are quite right on the fact that new regulations are very close, or in practice, or for effluent discharge, and you are largely talking about nonradiological now.

DR. STEINDLER: Right.

MR. SMILEY: Right. It is true if new regulations, state or federal, indicate that the water quality has to meet certain levels before discharge, then that is what will be done in our industry and we would be a part of that as well as every other industry. There will probably be a time frame associated with it, too, so people can be permitted to do something. It is interesting to note on that that, as I recall it, there are three major nonradiological constituents of interest, just to put it in perspective. One, as I recall, was ammonia, another fluoride, and a third was nitrates. Flowing rivers that we look at for our fuel cycle run average flows of eight to nine hundred cubic feet a second. And the only one that required large dilution was
[142]
ammonia. Fluoride is in the range of, I think we said seven; it might be closer to 70 cubic feet a second, looking at the number again, and that is part of the corrections we will make.

One of the others was a very few cubic feet a second. So it is not a serious problem. But if regulations come about, we will be requiring that those regulations be met within a time frame.
[143]

DR. STEINDLER: You have devised a model plant possibly by taking an average of the industry or possibly by adopting the most recent flow sheet that seemed to make sense and most of these adaptations are obviously necessary, otherwise you would be calculating yourself to death.

On the other hand, I think one of the better ways to estimate how sound that model is in relation to the industry is to provide some kind of spread of information on what are the limits, not from the model plant, of discharge, say,

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or impact, not from the model plant but, rather, from the extremes of current technology.

Is it reasonable to put, or would it confuse the issue to put into a document such as this the range of, for example, fluid discharge from all of the plants, from the plants that currently exist that you have records of? The Commission I presume has accurate records on what is being done. And would that serve any particularly useful purpose in identifying where the model stands in relation to the extremes and where the most extreme environmental insult could be expected to fall?

MR. SMILEY: Well, I think we could do that. It would surely lengthen the document considerably, create a lot of work.

DR. STEINDLER: That is not my object.

MR. SMILEY: My own feeling is — Under the present [144]
circumstances, I'm glad to hear that. Obviously I believe it doesn't change the conclusions. We had prepared information obviously to reflect — for that report, I mean — to reflect a conservative point of view.

For example, in fuel fabrication, the model — At least eight or nine out of ten fabrication plants were well below in effluents what we assumed for the model and accounted for about all of the UO_2 that was made. So to that extent I think you should feel relaxed about what the model does, in that it is conservative.

I think it would take a lot of extra work to put all of that in the report for every part of the fuel cycle.

DR. STEINDLER: Let me give you the thought I was trying to develop.

I would presume, and I haven't been a party to that kind of an investigation, so I'm just presuming, that if someone looks at a reactor, he looks at the reactor in question, and not the average of all of the reactors in the country, but in fact asks what is the impact on the environment of the particular reactor.

MR. SMILEY: Right.

DR. STEINDLER: It is that local impact that I think in a sense is missing here by averaging this thing out.

MR. SMILEY: I think I can handle that question.

We do exactly what you are suggesting in every [145] licensing action we take on a fuel cycle facility. For example, if we license a plant in Wilmington, North Carolina, or we license a plant in Pennsylvania, or wherever we license a plant, we look at all of the things you are suggesting.

We look at the worst case, we look at the total of the ologies, we look at the accident considerations, and we give this review to those plants. To that extent anyone can review what we have done in this regard and see how we reached our conclusions and everything is referenced.

A good example of that is one like the Midwest Fuel Reprocessing Plant where we just issued a Final Environmental Statement and a Safety Analysis Report. Everything is in there. But to put up a model that would serve the industry, the averaging, a conservative averaging looked to be a good way to go, because if one reactor, for example, got a little advantage because it might have gotten its fuel from a mill which was slightly higher in effluent, another one got its fuel from one that was low — In other words, for this document an averaging looks realistic.

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But every plant in the fuel cycle as it is listed goes through the very review you are asking about.

DR. STEINDLER: Let me mull that over and frame another question later.

Is it conceivable — I don't know whether this is a question for you or for Mr. Murray. Is it conceivable that [146]
people would assume that having defined the fuel cycle industry by this series of model plants that are connected by truck or rail or whatever, that from here on out the industry is going to be required to provide plants that follow these effluents and no others as a maximum?

If the answer is "no," I will back off very quickly.

MR. MURRAY: My answer would be that anything is conceivable, Dr. Steindler.

DR. STEINDLER: I didn't mean it in that sense.

MR. SMILEY: I think I see what you are getting at. What we reported was the industry today conservatively. In other words, if we were to look at the numbers from each plant, you would come up with lower numbers than we have here. We took a conservative point of view, and we haven't closed the door as to the future.

I might point out that that has come up in several comments that have been brought to us. We have seen industry and other Government agencies comment on the fact that we have made a rule. Now is this rule for all time? No, it is not; it is reviewed.

Our point of view is that probably in the order of a few years, maybe four or so, when we get more operating experience on the reprocessing plants, we will probably revise that.

Now we are working on as low as practicable, and [147] we do intend to come up with as los as practicable for all plants for the future. We have a contract with one of the National Laboratories now to look at as low as practicable.

Every new plant that we putup — Maybe this is more to your point. Every new plant that has been constructed that we make a licensing decision on is looked at on the basis of as low as practicable, using the best possible technology. And even in the backfitting of old plants coming up for renewals, this is a consideration.

Certainly we are requring that any plants that had been put up before NEPA use the equipments in that plant to its maximum capability. This is another consideration. So you can look to the future I think to see numbers come down, because the technology will improve and our regulations — We get so involved because we are looking at as low as practicable right now for every step in the fuel cycle.

Does that help?

DR. STEINDLER: Yes. That's fine.

DR. GEYER: I will go back then to referencing some pages and asking for clarification.

On page C-30, the first sentence at the top of the page, it there mentions the use of an annual flow —

MR. SMILEY: C-30?

DR. GEYER: C-31, the top of the page.

MR. SMILEY: Oh, yes.

[148]

DR. GEYER: By "annual low flow rate," what do you mean? Is that the low average year or is it the — I'm just not clear.

MR. SMILEY: It is probably the critical flow, but I would like to ask a member of my staff about that. I'm afraid I will have to look into that and let you know that later.

DR. GEYER: All right.

On page E-23, some more information with regard to dilution. There is a sentence just below the center of the page that says:

> "Thus subsequent dilution of the effluent by the receiving body of water is required to reduce the chemical concentration to these recommended levels for drinking water supplies."

It would seem to me to be desirable to discuss that matter more fully because the water may already be close to the limits permitted for drinking water supply. What would you do under those circumstances?

MR. SMILEY: If I'm not mistaken, I think that when we said we need a certain dilution or certain flow, like 600 cubic feet a second, I think it takes into account the concentrations upstream as well as uses downstream. Do you follow what I mean?

In other words, when we say 600 cfs, we indicate [149] there is a certain ammonia concentration in the water upstream so it does, to answer your question, take into account the level before we allow the plants to discharge.

DR. GEYER: Of course if you use an effluent standard, this problem disappears.

MR. SMILEY: Right. It disappears for us, it doesn't disappear for the people running the plants I'm afraid.

DR. GEYER: Going back to page S-29, the summary, you have referenced this survey to open pit mining, whereas in the future it appears that the major source of uranium ore is going to be underground mining. What will be the problem with regard to mine wastes when this change takes place?

MR. SMILEY: First I would like to say Yes, I agree with that observation, it looks like our reserves for the future will be more in the underground mines. We picked the open pit, because we felt it had the largest effect on the environment, certainly in terms of the overburden, the amount of land disturbed.

DR. GEYER: During mining this is true, but if in fact the mine wastes themselves are put back in the pit and it is graded over and planted, this sort of thing, maybe the long-term effect is not as much as having these tailing ponds at an underground mine.

[150]

MR. SMILEY: I think that could be quite right. When we mention that, we don't put a time limit on the amount of time it would take to put out another edition of this thing. We want to keep it upgraded.

I would say if we were doing this several years from now, we might well switch and say now in the survey the mine is an underground mine. I think that is very well taken.

DR. GEYER: On page S-32 there is, in the middle of the page, a statement that:

"Two curies of activity per annual fuel requirement are discharged in the tailing solution and thus are returned to their point of origin in the ground."

This may be true in the sense that they are returned to the ground, but not necessarily to the point of origin.

MR. SMILEY: I think that that is careless wording. I agree with you.

CHAIRMAN PAGLIN: Mr. Murray and Mr. Smiley and Dr. Pitman, as you can see, theBoard has some further questions of the Staff, and we would like, in consideration for the other participants who are on our schedule this morning, in order not to run too far behind, we would like to resume our questioning of the Staff at the conclusion of the other oral presentations, probably either at the end of today or [151] perhaps the end of tomorrow.

MR. SMILEY: Fine. No problem.

MR. MURRAY: We plan to be here throughout the hearing, Mr. Chairman.

CHAIRMAN PAGLIN: Fine. Thank you.

All right, then the next oral presentation is to made by the U. S. Environmental Protection Agency, Mr. Rowe.

STATEMENT OF W. D. ROWE ON BEHALF OF THE U. S. ENVIRONMENTAL PROTECTION AGENCY

MR. ROWE: Mr. Chairman, Members of the Board:

I am William D. Rowe, Deputy Assistant Administrator for Radiation Programs of the U. S. Environmental Protection Agency. I am pleased to present the views of the Environmental Protection Agency on the important subject of this hearing.

Since we have submitted detailed written comments to the AEC on the Federal Register notice and the Survey

Report, I will restrict my remarks to highlights of that review.

The hearing represents, we believe, a recognition of the importance of considering the environmental impact of other components of the uranium fuel cycle in making decisions relative to nuclear power. Such impacts will occur in varying degrees when nuclear power generation capacity commitments are made and knowledge on the extent of these effects is essential in evaluating alternative sources of energy with [152] their differing potential effects on man and his environment.

We believe that a better knowledge base for the decisions required on the impact of the fuel cycle can best be achieved on a generic basis rather than by a case-by-case examination of individual reactors. For this reason, we support the principle of evaluating the impact of the uranium fuel cycle on a generic basis.

The ultimate aims of this approach should be to compare all energy cycles on a cost-benefit basis and to pursue national decisions on which power systems are best to satisfy the country's demand for power. The information being developed in this hearing is important to these goals.

Ideally, we believe that in evaluating the environmental effects of the fuel cycle as related to a reactor, such effects, to the extent possible, should be related to the specific fuel cycle plants that support a given reactor. We recognize, however, that at present and for the presently foreseeable future it would be impracticable to adopt such an approach because the patterns of the industry are changing and the knowledge base of the environmental effects of various components of the cycle is being added to as technology changed. This condition also argues, we believe, for the

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generic approach used by the AEC in its Survey Report which supports the proposed rulemaking.

Neither of the two alternatives proposed in the [153] rulemaking specifically addresses the problem of periodic review in a specified time period. In view of the expected growth in nuclear power and the development of new and improved technology, we recommend that the AEC make it clear that it does not intend by this rulemaking action to foreclose future consideration of fuel cycle impact as related to reactors.

This assurance can be given by stating in the rule that the environmental effects of the total fuel cycle will be periodically evaluated and updated as new information is developed. We believe a period of two years should be specified in the proposed guidelines as the timeframe over which they would be effective.

Given such assurance we would recommend that Alternative I be adopted with the understanding that the first reassessment would take place within that two-year period. In this regard we can accept on a provisional basis the current Survey Report as providing adequate consideration of the environmental effects of the present uranium fuel cycle for purposes of the rulemaking.

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[199]

AFTERNOON SESSION

2:00 P.M.

CHAIRMAN PAGLIN: Will the proceeding come to order? The Board has determined and with the kind cooperation of Mr. Roisman, in order to accomodate Dr. Pittman, we would like to put some Board questioning to

Dr. Pittman at this stage and then we will recommence with Mr. Roisman's group.

So the Board Members have questions of Dr. Pittman at this time. Dr. Steindler?

DR. STEINDLER: There has been some discussion and you alluded to it in your testimony regarding our present ability, the present ability of the nuclear industry to retain high level wastes in a safe fashion. Is there anything that your studies have shown that indicates that at this point, as apparently practiced in the industry, the retention of high level wastes is a real problem?

DR. PITTMAN: There is nothing that I can see with regard to the commercial high level wastes, either from the point of view of what the industry will have to do under the regulatory scheme, or what the AEC will have to do, once the solidified waste is delivered to them, to us.

The possible retention for up to five years in stainless steel tanks, as an acid solution is the type of thing we have had at Idaho Falls for of the order of ten years, and the type of thing we have been doing in stainless [200] steel tanks at Idaho Falls for ten years, retention in acid solutions with no problems at all.

The next step the industry has to carry out is if they decide to wait five years and retain it as acid solution, to solidify the material, there are several methods of solidification, the method that was chosen by the first company who is going into business this year is that of using the fluid bed calcination technique, which again is one that has been demonstrated at Idaho Falls for ten years, and they then put that into cannisters and store it in basisn of water.

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All of this is under the license control of the regulatory group. The basin storage is similar to the type of storage that is used at reactors for storing spent fuel elements that have essentially the same fission product contents, they have a lot more, has more plutonium than uranium, so it has a problem of material that we don't have in the wastes.

The sealing by ten feet steel cannisters is certainly no breakthrough in technology, it is something that can be done and has been done in many industries for a long period of time. The transportation of the spent wastes in the casks of the same type that have been used to transport spent fuel in my opinion is a demonstrated technology.

And the engineered surface storage of these wastes once delivered to the Commission is purely an engineering [201] application of technologies that have been known for many years and that have been used by the Commission in not waste storage, because in our previous systems we used other methods, but in my opinion there is no technology that needs to be developed in order for the whole storage of wastes from the time it is generated and it is kept in manageable sized containers, from that point on, to the time we get it and store it in the engineered storage in managably sized retrievable, monitorable, maintainable containers.

The engineered storage, you have heard the words, we have designed for one hundred years, that is purely meant to show that the basic basins, the facilities in which these materials will be received and stored, are built with the latest technology for concrete and steel, and will certainly last a hundred years, probably a lot longer with adequate maintenance of the facilities.

We do not necessarily expect a given cannister delivered to us in 1983 to not have some corrosion problems in one

hundred years. They can quite easily be overcanned or recanned or maintained and we have techniques built into the engineered storage facility that will allow us to detect when there is a leak before it becomes a major leak, and to identify which tank is leaking, to take it out and repair it or repackage it.

DR. STEINDLER: Then the picture that I think I am [202]
beginning to see here is that at the moment it appears that the high level wastes are retainable in the individual reprocessing facilities, and that the engineered storage area will consolidate the waste surveillance and handling problem into one site and that is really its major contribution, not the development of some new technology.

DR. PITTMAN: There is nothing new being developed in the engineered storage facility. We are looking at better techniques of removing the heat, more efficient techniques of removing the heat than maybe used before. But it is purely an engineering application of known technology we are using.

And the idea of bringing these together at one site under the auspices of one agency, namely the Atomic Energy Commission, has to do more with the assurance of continued control for whatever period of time is necessary.

DR. STEINDLER: Thank you.

CHAIRMAN PAGLIN: Dr. Geyer?

DR. GEYER: Dr. Pittman, I refer to Table H-1 on page H-3 of the Survey Report.

DR. PITTMAN: Yes, sir.

DR. GEYER: There appears there numbers of shipments per model LWR annual fuel requirement. The question is will these remain constant with time over the years?

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DR. PITTMAN: Per annual fuel requirement as it is now known, they will remain constant for the waste.

[203]

There are several factors which might make it fewer shipments, because we are assuming that the waste material in the can, has a very low density, and we can only get the equivalents of 3 tons of fuel reprocessed, the waste from three tons, into a can.

We have under development methods of solidification which might cut that down by a factor of 3 or more in the amount of wastes that you can get into a can. If it makes any sense. We feel that the packaging and shipping and storage of the low density material that is being produced by the first reprocessors going into business is perfectly safe, but there may be some economics in being able to get more of this material into a given can, which would cut down on the number of shipments, per year, per reactor.

DR. GEYER: I assume then that one could make an estimate of the number of model LWR's or the equivalents of them that would be present 30 years from now, and that would be the number of, multiplied by one, would be the number of shipments of high level wastes?

DR. PITTMAN: I don't have the figures in my head for the number of shipments we are assuming will have to take place per year from the economy and, the nuclear economy in the year 2000. I do remember a figure, I will be glad to submit a corrected figure for the record, but I do remember a figure that in the year 2000 there will be 8,000 cans [204] delivered during that year, if I remember the figure correctly. In other words, the slope is going up very rapidly towards the end of the century.

DR. GEYER: But it would be desirable to have in the record some of the long term estimates, just to see what the scope of this problem may be in the future.

DR. PITTMAN: This would be for the entire economy?

DR. GEYER: That is right.

DR. PITTMAN: We have the figures. I can get them for the record.

DR. GEYER: It would be nice to have them for say 25 and 50 years, just to see what they might look like.

DR. PITTMAN: Yes, what we are assuming is this one facility we build will handle everything generated through its end of the century. And then there would have to be more facilities, maybe expansion of this one, maybe new facilities or maybe other techniques would be used by that time.

DR. GEYER: My next question bears on the same problem in a sense. There will certainly be a considerable amount of this material in transit and since the cell storage under water of the high level waste is apparently being considered to be an interim measure, to be subsequently replaced by permanent resolution of the storage problem, why [205] not leave the wastes where they are?

DR. PITTMAN: This is one of the things that is being given consideration, not so much from the standpoint of leaving them where they are in the basins of the reprocessor, but rather in the selection of sites.

One of the factors we are looking at in the selection of sites is does it make sense for us to have several government owned and operated repositories, right adjacent to or near the location of the reprocessing plants, so the initial

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shipment of this waste while it is at its hotest, namely after ten years, would be minimized?

DR. GEYER: Why not right on the site?

DR. PITTMAN: It is possible right on the site, under government control. We are still assuming government control is necessary. This is being looked at and evaluated against a single repository. The early indications seem to give the economics in favor of one single repository versus a series of small ones, but that is only economics.

DR. GEYER: Thank you, sir. That is all.

CHAIRMAN PAGLIN: Thank you very much, Dr. Pittman.

DR. PITTMAN: Thank you, sir.

[206]

CHAIRMAN PAGLIN: We may have some further questions for the Staff, as I indicated earlier today, at the conclusion.

Thank you, Mr. Roisman, for your cooperation.

We will now proceed with you. Can you tell us the order in which your witnesses will appear?

STATEMENT OF ANTHONY A. ROISMAN, on behalf of the Consolidated National Intervenors and the Union of Concerned Scientists.

MR. ROISMAN: My name is Anthony Z. Roisman, Mr. Chairman, and I have a panel here today on behalf of the Consolidated National Intervenors and the Union of Concerned Scientists. With me is Dr. Henry W. Kendall, who is a nuclear and high energy experimental physicist and Professor of Physics for the Massachusetts Institute of Technology, and Dr. Edward P. Radford, Professor of

Environmental Medicine, School of Hygiene and Public Health, Johns Hopkins University.

Also with me is Mr. Jim Beaverman, a law student at George Washington University Law School, who is working with us under an environmental program that is run at George Washington University.

I will begin with a very brief presentation on some of the legal questions, and then Dr. Radford will speak and then Dr. Kendall.

Because Dr. Radford will not be available tomorrow [207] due to a substantially earlier commitment, I would appreciate if the Board would ask questions of Dr. Radford following his presentation, and, because I can be here tomorrow, if necessary, if the Board would not mind postponing questions for me until tomorrow morning. If they have questions for me I will be glad to return for that purpose.

I should make it clear that as a lawyer, of course, I have no technical expertise, and purport only to talk about legal situations and, to some extent, to give you a brief outline of where we are going.

CHAIRMAN PAGLIN: All right. We will go ahead on that basis, Mr. Roisman.

MR. ROISMAN: Thank you.

I think that this hearing today is an extremely important event in the continuing discussion with respect to nuclear power generation. It is quite possible that this is the beginning of the end of the further development of fission nuclear power in this country. I don't say that from a technical standpoint; both Dr. Radford and Dr. Kendall and a number of the other people who have been associated with our

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organizations have raised serious and important questions involving nuclear safety which of course must be resolved prior to the licensing of nuclear power plants.

But even assuming that the optimistic view of some that those safety problems can and will be resolved, there [208] is the continuing question as to whether or not the public, once it hears the real story about nuclear power, will turn it down.

I think that the past actions of the Atomic Energy Commission, the nuclear industry, and the utilities have to a large extent created a potential for public reaction against nuclear power which will end the fission nuclear program. We are all aware of what those secrets have been in the past. A congressionally created Advisory Committee on Reactor Safeguards continues to keep its meetings closed to all but utility and vendor and regulatory staff personnel. The Atomic Energy Commission continues to take subjects as important as nuclear waste disposal and treat them in a cavalier manner that we find them treated in this environmental survey.

They continue to raise the issues of the environmental fuel cycle in the most obtuse manner, and subject it to this type of legislative hearing, while refusing to face up to the fact that the public demands the right to cross-examine and to have discovery on these issues, that we are not satisfied with Mr. Pittman's well intentioned, but, we think, not at all well explained position with regard to the ability to handle nuclear wastes for hundreds of thousands of years. He has in his own words referred to it as a program of perpetual management.

[209]

I must say, as a former philosophy major in college, I have some concept of the term "perpetual." I think the

public deserves theright to ask the question, What does that mean?

Dr. Ralph Lapp has pointed out if we should have the incredible nuclear accident, namely, an emergency core cooling system failure following a loss of coolant accident, it is quite possible that the public's reaction to that event would be a moratorium on nuclear power for a hundred years.

I posit when the public finds out that nuclear power plants create a product, not in nature, a product which has a half-life of 24,000 years, and that remains lethal for hundreds of thousands ofyears, that it may very well say to this country, We are ready to find the alternative, and we don't care about thequestion of safety, because you have led us down the garden path so often, you have hidden the facts from us so frequently, that we do not believe you when you tell us that this generation and the generations to come will be safe for ever from something which we need not ever face if we simply do not create it in the first place.

Perhaps the best example is to look at the press statements that come from the Atomic Energy Commission. And many of you have probably seen that great poster with Johnny's addition on it: Four truckloads of plutonium heat [210]
New York and light New York City for a year. How much plutonium do you have at the end of the year? Five truckloads.

Johnny's mathematics doesn't tell you how much nuclear waste that is not useable in that reactor that you have at the end of that year, it doesn't tell you how much longer you are going to have to control that waste. It's that kind of false addition which has made the public extremely skeptical about nuclear energy.

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And if nuclear energy is capable of fulfilling its promise, there is some doubt as to whether or not the public is prepared to accept it now that they have come to this juncture.

It is not surprising that the environmental survey of the nuclear fuel cycle has come out at this time. While we are not concerned here with the motives of the Atomic Energy Commission, but rather with their actions, we do think it is important to note that as long ago as when the Calvert Cliffs decision came down the Commission was put on notice by environmentalists and others that their failure to treat the environmental fuel cycle in individual licensing proceedings was a major error, comparable to the same errors that produced the Calvert Cliffs decision.

Now, some year and a half later, the licensing proceeding which was chosen by intervenors to raise that issue, Vermont Yankee Nuclear Power Company, is drawing to a [211]
conclusion, and the New England Coalition on Nuclear Pollution and the National Resources Defense Council stand ready, if a license is issued, to take that issue to court.

We think the Commission is fully aware of that. And that one possible reason for holding this hearing at this time was in order to have before the court at the time the hearing on the real issue is presented, something that will make the Commission look like it is moving at better than a funeral rate, and it is not making a complete mockery out of the National Environmental Policy Act.

In that context, what this hearing represents is a form of ECCS, emergency core cooling system, and it should not be in any way confused with an adequate environmental study of the nuclear fuel cycle. It is not. It doesn't even purport to be, although the cover, as Dr. Steindler pointed out, does to some extent mislead us as to whether or not it discusses all of the issues.

One of the most important factors that we think is lacking in this report is the failure to distinguish between design objectives on the one hand and performance on the other. The history of the Atomic Energy Commission and the atomic energy in general has been one in which design has rarely been achieved and that performance has represented a significantly different figure.

Let's talk about a few examples that I think will [212] point up this point.

First, we were told earlier today, and it appears in the report, that we can anticipate that one-third of the core of a thousand megawatt nuclear power plant will be replaced each year. And from that the entire environmental survey of the nuclear fuel cycle begins.

I am informed that the Regulatory Staff has taken the position in Point Beach Unit No. 2 that in order to cope with the inability of the Staff to now analyze the problem of fuel densification, that the Staff is recommending in Point Beach Unit No. 2, close to a thousand megawatt reactor, there be full core replacement each year; since they don't know what will happen to fuel densification they would rather remove the rods and assume they are all crumpled.

I don't mean to quarrel with the premise; I merely point out that represents the tripling of the amount of fuel going from power plants if that unit becomes the standard.

In the waste disposal area, the history has been abysmal. Mine tailings were used to put into the foundations of homes in Colorado. We have had problems with leakage at Hanford. At the reprocessing plants the releases of Iodine-131 and Iodine-129 were grossly underestimated, and re-evaluations are having to be done.

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In another specific example, we find many power plants in this country are having to now be re-evaluated to determine [213] whether or not the steam lines and other high pressure water lines ran so close to the building that had the control room in it, if there were a postulated break of those pipes they might wipe out the control room. Two plants, Prairie Island and Kewaunee plants, may in fact have to be totally redesigned because of the problem.

Significantly it was not the Atomic Energy Commission which discovered the problem, but an anonymous letter sent to the Commission advising them of it.

These events are not designed to instill confidence in the public or to make us believe that the way to evaluate the environmental fuel cycle — the nuclear fuel cycle's environmental impact is to begin with design objectives which we don't necessarily know can be met. We have been told that this report represents an extremely conservative evaluation of what will actually happen at the site. Yet in the presentations submitted by Babcock and Wilcox, on pages 2 and 3, they tell us that they want to be sure that it is made clear that the modeling approach to the fuel cycle industry is "not intended to represent any specific facility and should not be construed or applied as operating criteria or limits for specific fuel cycle facilities."

It is this type of "Now you see it; now you don't" in which we do our environmental analysis based upon one standard and set criteria at a different level altogether, that [214]
continues to make public confidence in nuclear power fall.

Another aspect of the fuel cycle report which is lacking is an objective analysis of the question of accidents. In our opinion the entire accident analysis should have in-

cluded the types of assumptions which Dr. Steindler referred to earlier this morning, and some basis for reaching those particular assumptions.

In our presentation today we will begin to discuss the question of what is the credible accident in the nuclear fuel cycle, and how does one go about determining what constitutes credible and incredible.

I need not stress to all of you the significance of the terminology "credible" and "incredible." It represents an extremely important line that, once drawn, distinguishes between those things against which plants are designed redundantly to cope with, and those things against which no designs exist.

If an accident is incredible, the plant has no designs to cope with it, unless they happen to accidently be there. If the accident is credible, redundancy is required.

The drawing of that line is extremely critical. And yet the fact remains that today no reliable, competent figures exist to determine the probability of accidents, or any way to determine what we should use as the criteria for [215] setting the credible and incredible line.

If we continue in the present procedure it is our position that what will prevail is a situation in which there will be no legally sufficient environmental survey of the nuclear fuel cycle. In our opinion the alternative suggested in the Commission's Notices of Hearing do not meet the objectives of the National Environmental Policy Act or the Commission's own responsibilities with regard to the radiat-on dangers from the operations that the Commission controls.

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It is not a substitute for the review required under the National Environmental Policy Act to hold a legislative

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type hearing and produce a document which contains figures which are then to be introduced into the record of an adjudicatory hearing, namely the licensing of nuclear power plants, and are not subject to discovery or cross-examination.

Such a route would allow the Atomic Energy Commission or any other agency that holds adjudicatory hearings to hold legislative type hearings to get all of the important numbers and then in adjudicatory hearing, in which the numbers would be installed in a pre-determined place, in a pre-arranged report.

We feel that the only possible solution is to have some type of a full generic hearing. The biggest single problem is that we are discussing the question of the environmental impact of the nuclear fuel cycle in the context of the continuing licensing of the plants which produce the problem.

We are not having an opportunity to consider whether or not those plants should ever begin to operate at all. This morning we heard from the Atomic Energy Commission witnesses that it might be as late as 1983 before the first interim storage sites would be needed, and from that the inference is drawn that therefore there is nothing to worry about, fellows, it won't be 1983 until we actually have to [217] have one running. The problem is it is in 1973 we are producing the wastes, and if in 1983 we discover that the dream of the adequate interim storage site is like the dream that Lyons, Kansas had a perfect salt mine, there is nothing we can do about it, because the wastes are already there, ten years old and ready to go.

And the issue, the issue that the Commission refuses to face up to is can you continue to produce the wastes, can you continue to produce the reprocessing plants, can you

continue to do the mining without asking the question of whether or not in the first place we should be pursuing this course of action.

We suggest, therefore, that an alternative 3 be adopted, and that that alternative that the Commission convene a full generic hearing on the question of the nuclear fuel cycle, which is subject to full adjudicatory rights, that a notice go out throughout the country, participants in individual licensing proceedings, that this will be the adjudicatory hearing on the question of the fuel cycle and that the results of this hearing will be put into environmental impact statements as appropriate.

We discuss in much more detail in a legal submission which we are making shortly the exact mechanism for this type of hearing. But, Your Honor, the salient points are, one, it is adjudicatory, and two, once it produces [218] an environmental impact statement and board findings, it should be subject to periodic updating. Now you will note in some of the submissions of people who might have been considered to be on the other side from us in this proceeding there have been suggestions to the effect that something like this be done.

But let me stress that the line that distinguishes us from those others is that we continue to insist upon the Administrative Procedures Act protections of discovery and cross-examination. No subject is more needy of those procedural rights than the subject of the fuel cycle. Long suppressed in terms of public exposure, now kept at a low key level in this type of legislative hearing, it is a subject which demands investigation.

We note that the proponents of nuclear power who have been frequent and vociferous in their support have been

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significantly silent at this hearing, making 15 and 30 minute presentations, with the exception of the Atomic Industrial Forum, which is not taking a position on the merits of the two proposals.

We do not think that is accidental. The subject is one of great embarrassment to the industry. It involves the critical question, do we want nuclear power or do we not? And we feel that the past performance has been an unwillingness on the part of the Commission or the industry to openly [219] discuss this subject.

Until we can cross-examine and discover with regard to it, the subject still remains essentially a closed book. Thank you.

Dr. Radford will now begin his discussion. We have distributed previously the consolidated National Intervenors Statement with respect to the oral presentation, which outlines some of the points that Dr. Radford will make. We have also distributed this morning to the Board an outline that is in more detail of his comments.

He will be available for questioning at the conclusion of his remarks.

Thank you.

STATEMENT OF DR. EDWARD P. RADFORD ON BEHALF OF THE CONSOLIDATED NATIONAL INTERVENORS AND THE UNION OF CONCERNED SCIENTISTS.

DR. RADFORD: Members of the Board, I am Dr. Edward P. Radford, Professor of Environmental Medicine at Johns Hopkins University, in the School of Hygiene

and Public Health. I welcome the opportunity to appear with the National Intervenors and the other groups not because in all details my position has been identical with theirs as just in some detail has been expressed by Mr. Roisman.

Before I begin I would like to make my position clear, but I do share some or many of the concerns. It has [220] been my experience that throughout my contact with the whole issue of licensing of nuclear facilities, that some overall view of the environmental impact of these developments be taken.

My attempts to do this at the various hearings that I have participated in have been uniformly negative, uniformly struck down as not responsive to the particular hearings. So that what I am saying today comes from a long series of episodes in which I have attempted, unsuccessfully, to bring these matters to the attention of the public and particularly to the licensing agencies.

Now, to begin with, my position with regard to the development of fission reactors is somewhat different from that expressed by Mr. Roisman and I feel it is appropriate to point out that we do not insist in our organization on uniformity of opinion.

My feeling has been that in many ways the development of fission energy has come at a very opportune time, that, in fact, our need to displace fossil fuel, such things as coal and oil as fuels, is urgent and is pressing. On the other hand, I also believe that, as I have indicated in the outline, that the whole process has been very much oversold in the sense of both economic and in terms of the alleged lack of impact that this will have on the environment.

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I would like to say just a word about the availability [221] of nuclear fuel. I have in the past in public expressed the opinion that breeder reactor program is critical to the development of the fission industry.

In this regard I am in no way different from former Chairman Seaborg, and all of the rest of the commissioners, President Nixon, et cetera. It stands to reason that unless we have an adequate supply of low cost fuel for these reactors in 30 or 40 years, then obviously we will not have a nuclear program.

And in effect then one must say what will be the environmental impact of the breeder reactor which must come on line as quickly as possible, in order to provide the available fuel. I don't believe that at this time it is worthwhile to discuss this in detail, but I feel that as far as the safety features are concerned, about which I will not speak, the safety features of the breeder reactor remain very much in doubt, and therefore the developments must be done on a much more cautious basis than has been done for the light water reactors, and for that reason may be delayed, in fact in my opinion it is unlikely that before the year 2010 and based upon my evaluation of the industry, it will be that long before we have a significant commercial breeder reactor program that will be available, if ever.

So much then for my position with regard to the development of the industry itself.

[222]

With regard to the information problems that have arisen, to which Mr. Roisman referred briefly, I would like to point out that it has been, as one has attempted to inform himself as much as possible, and in a responsible way, it has been a frustrating experience to attempt to find out what in fact really happens.

Too often its reaction has been, and it was such at the preceding hearing, in the as low as possible hearings last summer, too often the attitude has been, well, you don't know what is going on, therefore how can you criticize it.

I submit, Gentlemen, that it is not the responsibility of the people who have many other responsibilities besides this to go and ferret out the information. Quite the contrary. I think the whole record should be open, and it has signally not been laid open. To give you one specific example, in response to questioning last summer, I was asked whether I was aware of the quarterly reports of the Dresden Nuclear Power Reactor and since I said I was not privy to that information, it was made available to me.

But was it made available to me? The material I received had deleted all of the scram records, it had no indication of the occupational exposures of the workers in the plant. In fact in one case it simply gave the release data only, part 6 I believe of that particular quarterly report.

[223]

Now it is my understanding that these quarterly reports are part of the public records of the plant. And the question is why was this deleted when it was brought up as an issue that I was uninformed on? Especially important I think with regards to the environmental effects is that very little in the way of actual monitoring data in the field have been provided from operating reactors.

By and large all of the radiation doses that are being expressed for the public are calculated doses. I submit that the industry is only just now developing, that there are enough questions in how you monitor, what you monitor, et cetera, that there should be a much more vigorous effort made by someone, and I will just say a word about that, but made by someone to actually monitor what comes out of

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the reactor, not simply take the words of the operating plants.

They may be right, but they may be wrong. Now the someone who should do this, as you know with the Northern States opinion by the Supreme Court, the whole matter has been tossed back to the AEC. In other words, the states feel that they are preempted from any significant inputs into the licensing, or even to some extent the monitoring programs.

Certainly they do not have the resources under our present allocation of funds to do this by and large. So that I think that this is an issue that is relevant and when I discuss later the questions of what actually has been [224] the operating experience, there are gaps in our information, unquestionably, and it is a question of whose responsibilities is it to fill in this kind of data.

To give an illustration of the fact that there can be major differences, in the extent of the environmental impact with a single plant, in the testimony last summer at the as low as possible hearings, I gave some estimates of what I thought the Dresden Nuclear Reactor would be causing in the way of a radiation dose if they were operating at 90 percent capacity for a year.

The company, the General Electric Company, made other estimates. I later pointed out that in a letter from Lester Rogers, that the AEC measurements differed from the company's by at least a factor of about six, if not more, higher.

In other words, field measurements carried out by AEC had indicated the company's estimates were decidedly low. This is the kind of thing that keeps popping up in this.

Of course fundamental to all of this is what has been the operating history of the plants.

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Now it is significant that in the 1971 AEC releases on what the radiation emitted from the plants had been for the first time, at least to my knowledge, the rated thermal capacity of the plant and the actual thermal production of the plant were given on the table with the radionuclides, so for the first time you could calculate what the operating percentage was and then if you were inclined to do so, you could say, well, if they operated at 90 percent of capacity, this is what the radiation releases would have been.

Obviously, the utilities are doing their level best to make them operate at 90 percent of capacity. So here again is a way in which you can extrapolate. But all too often in the past it has been impossible to find the actual operating experience.

Now I turn finally in my general comments, to the issue of whether the evaluation of the health risks have been realistic or not. I first had experience with this in 1948, as a radiological officer at the Sandstone nuclear bomb test held at Kwajalein and Eniwetok. We were told in a briefing before the shot that there was essentially zero probability that there would be any significant fallout on the islands on which the suppoerting personnel were living, namely Kwajalein. One item, of course, was the prevailing wids were not in that direction; two, they had [226] already figured the meteorology in advance before they went with the shot, et cetera. Needless to say, we had rain out on Kwajalein, such that on the canvas of the tests, we were recording with our Geiger counters, which was essentially beta gamma, approximately 5 mr per hour, which is not a negligible radiation dose. This was my beginning intro-

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duction into the ability of experts to predict such things. There were some other things such as the extent of stratospheric penetration, which was also wrong.

Coming up to the more recent past, Mr. Roisman has already summarized some of the things that have concerned me in the past, where in fact the Atomic Energy Commission failed to anticipate a problem. I think the fallout problem from I-131 is a classic; they weren't even measuring it until it became apparent it was one of the major routes of exposure to the population. Similarly, the fact that tritium is a fission product was not discovered until 1959, long after the first fission.

I don't mean to harp at these, because I think, after all, we are all human and we don't necessarily know everything, but I am merely pointing out that the image AEC has project consistently in the last three years is "We know all about everything, and we are telling you it is fine." I am saying the record does not necessarily bear this out. That perhaps is one reason we are having these hearings.

[227]

Now with regard to the question of the linear nonthreshold dose response relationship for radiation effects on man, we have heard a lot about this; I have expressed myself vigorously on this point and I had occasion to do so as a member of the National Academy of Sciences Committee reviewing the biological effects of ionizing radiation. And that report has now been issued, and I see no evidence — I have a copy of it here, the effects on populations to exposure to low levels of ionizing radiation. I see no evidence that the contents of this report, which is certainly available, have been taken into account in looking at the risks to the human population.

Now, the fact of the matter is, as I become more involved in the question of the safety or non-safety of nuclear

facilities, was that it was apparent that the thinking of the regulatory agencies, by and large, was not to accept the linear nonthreshold dose response curve. In other words, they made the assumption that such things as the effects will be so small as to be nondetectable; therefore, we don't need to worry about them, or you can't measure the increase in cancer rate; therefore, it is not important. I submit that that is a mistake, and in fact, then, by and large, the attitude has been not to take this seriously.

Now it turns out, and I think on any reasonable **[228]** reflection, any scientifically knowledgeable person would realize that this is an extremely fundamental question that we are addressing when we look at an environmental agent which at any significant increase is thought to produce an effect on the human population.

We are in quite a different position than we are in regard to a lot of our environmental effects. We may turn up many chemicals which have the same process and we will have exactly the same dilemma. In most cases these chemisals can similarly be deleted from our industrial process, never used. But unfortunately radioactivity is a necessary concomitant of nuclear power developments and, therefore, we must live with it in context.

Now I feel that the situation has improved in this regard and the as low as practicable hearings that were held last summer were a reflection for the first time the AEC began to take seriously the issue of how much ought to be released, what risk to the public ought to be an acceptable risk, which is the tough problem we have to try to reach an answer to.

Now, unfortunately, in those hearings or in the proposed changes to 10 CFR Part 50, that they were addressed to, I feel they over-reacted. They were recommending stan-

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dards that were so strict that they would almost inevitably be unmeasurable and, therefore, unenforceable. I say that is [229] almost as bad a situation as having standards that are clearly much too high. I will come back to this point by looking at some of the issues as we go along.

I would now like to turn myself to some of the environmental impacts of the entire fuel cycle that I see as of critical importance at this time. The first point has to do with uranium mining operation. The environment of the mines is just as important as the environment outside the mines. There is a tendency on the part of many people to say that environments are only what you can go outdoors into. That is not true. Houses are environments, work places are environments, and of course, we spend a substantial fraction of our lives in these environments, too.

Therefore, the mine environment is an important one for the miners. Exposure conditions in the mine are from the radon daughters, the radon comes into the mine air from the surrounding rock and waste water, et cetera, and they decay to short-lived alpha emitting daughters, which generally adhere to particles and are inhaled.

The BEIR report I referred to goes into considerable detail in updating the available information on the mining experience in Colorado and elsewhere. And I have since received some additional information from Sweden which is also very interesting. And very nearly confirms the same kinds of dose response curve that has been observed in [230]
Colorado and in Newfoundland. The evidence to date indicates — and I can put it in these terms — that the projected risk to the miners if the current standard of four working level months per year is adhered to, and that was fought vigorously by the industry, and to a large extent by AEC

as well, is that the increased cancer rate, lung cancer rate to the miners, they will have an increased risk of approximately 250 percent above the other working population not so exposed.

Now the question is, is this an acceptable risk? Are we requiring miners to accept this risk in order to work in the mines? I might say that the assumption I have used here is that they work 30 years in the mine, from age 25 to 55, let's say. If we reduce this standard to one working level month per year, which I believe according to the hearings would be very difficult to achieve in most mines, then we might have only an increased risk of 65 percent.

Now it has become apparent in looking at the data that the risk is increased proportionately both for smokers and nonsmokers. In other words, because a smoker has approximately 10 times the cancer risk as a nonsmoker from lung cancer, then in the miners, the smoking miners have approximately 10 times the risk that the nonsmoking miners do. But the proportionate increase related to the general population would be expected to be the same.

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One way, then, perhaps to reduce the risk to these miners, is to hire miners, only miners who don't smoke. I consider this a highly unlikely event, because in the first place, it is almost impossible to enforce. If you were invading the privacy of the individual's own home to see if he smokes or not, and I don't think you can enforce it. So I think we have to begin on the assumption that it is likely a substantial fraction of the mining population is going to smoke, whether we like it or not.

The second way in which this might be able to be dealt with, of course, is to use filtered air, use respiratory equipment. A close-fitting face mask has never worked in any

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mining operation, or in any industrial operation that I know of. Men doing heavy work simply cannot tolerate the increased work of breathing that a mask respirator has. Therefore, they take them off. So you have no hope there.

The third mechanism has been to develop a portable flow-through system, with an overline hood. This is cumbersome and very likely would have the same fate, but it is at least worth a try.

Another method obviously is to put the individuals on short shifts and in this sense, we would be in very good company, in that this is the way in which the AEC, or other nuclear facilities, deal with the problem of occupational **[232]** exposures elsewhere. If the individual receives his 5 rem dose, he simply is shifted to other work for the rest of that year. At least this is my understanding.

So we do the same in meeting these standards. May I point out that the current standard of four working levels per month, we translate into a dose of approximately 20 rems per year to the bronchial epithelium. This is well above — there is no real standard for the bronchial epithelium, but in terms of cancer risks in males, the bronchial epithelium is the most significant organ in the body, more so than bone marrow.

So if you are comparing it to the total cancer risk from whole body radiation, you get about 80 percent of it in the lung cancer situation for males.

Finally, there is the issue of using only open pit mining, which eliminates this problem. I am not able to determine whether this is economically feasible or not. I believe the document we have before us says that approximately 50 percent of all mining tonnage is done by open pit mining. Therefore, we will have to worry about the environmental

impact of that in another sense, not in terms of the occupational exposure in the mines.

In my opinion, then, in conclusion of this section, I would merely point out that the present standards for exposure of miners in underground mines to radon daughters is [233] too high, that we are asking them to accept to grave a cancer risk on humanitary terms, and I don't believe if the miners and the unions really understood what this meant that they would,either.

I am not going to say a great deal about the environmental impact of the residues and so on, because this has been covered fairly well elsewhere. I have really nothing much more to add. In the interest of time, I will move on. I have just raised the issue of occupational risk from radiation exposure in the mines. But this is a general problem throughout the whole nuclear fuel cycle. In other words, everywhere you have one of these facilities, you have workers. And these workers may have to enter areas that have relatively high radiation fields.

Now I have made some calculations on the risk estimates to the working population based on my somewhat modified version of the risk estimates that have been expressed for somatic effects in the report. I take full responsibility for these calculations; they are not necessarily derivable from these. At least one of the members of the Board knows I submitted my model to the as low as practicable hearings last year on how I achieved these estimates.

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When we consider high dose rate radiation, that is relatively sudden dose, which might occur for example in the case of a welder going into a reactor in order to fix a weld, and we have heard from the Consolidated Edison of New

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York that they had one such episode recently where they had to use 700 workers.

At high dose rates, five rems per year for 30 years, there would be an increased risk of cancer of 55 percent in females, and 40 percent for males. This is overall cancer risk for all cancers. In addition, in the females, if the female were exposed to this radiation dose at a time when she was carrying a fetus, the risk of cancer to the fetus would be 130 percent increased.

At low dose rates, that is day in and day out accumulation of dose, the corresponding figures would be reduced by a factor of five. I do this based on estimates of John Storer of the Atomic Energy Commission, with which I agree.

That is the effects, the somatic effects of radiation, are dose rate dependents when you are concerned with low LET radiation, that is gamma x-rays and most beta. That would be the principal occupational exposure in most cases. There the factor then would be an increased rate of about 11 percent in females, and 8 percent in males. But the dose, the effect on the fetus, if it is given over the entire
[235]
pregnancy period, would still be the same. Now if you require female workers in the plant or in any facility to cease work in the plants as soon as she was aware she was pregnant, we would not necessarily eliminate these problems.

First, with regard to the high dose rate, this does not matter when that occurs. If it occurred during the first two months of pregnancy, when women characteristically don't know whether they are pregnant or not, under those conditions you would still have the same risk.

But if you had the progressive or the low dose rate effect, then if the woman was eliminated from any exposure after she became pregnant, say in two months, that would reduce its risk to the fetus to approximately 35 percent increased risk to that fetus. Now the question is if you face workers in a nuclear facility with a document in which all of these estimates, or someone else's estimates, which I don't think can be very different, you sign this document accepting this risk, how many workers would you get?

I don't know the answer to that question. But I have a strong feeling that one factor that emerges from this kind of analysis is that almost certainly females should be not exposed wherever possible, to any of this kinds of radiation exposure.

I would like to point out a few other things with regard to the source of radiation exposure under the occupational conditions.

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First, in looking for evidence of what the occupational exposures have been, as I mentioned, the reports I received did not give any of the film badge or other dosimetry data on the workers in the plant for Dresden reactor. But I was given the one from Humbolt Bay and it indicates at least a small percentage of the workers in the plant are receiving between 1 and 5 rem per year according to their measurements.

This kind of information, should certainly be available to the union, for example, the Atomic Workers Union. What are the experiences from the actual measured dose that these people are getting? Not some theoretical calculated thing, but what are they actually getting?

The second point to note is there is a linkage between the reactor operation and these industrial exposures. In that

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if you have a very pronounced fail fuel rate, obviously you are going to get more crud in the reactor, more in the pipes, and you will have a higher radiation field in the vicinity of the parts of the plant in which you must operate.

So it is a question then of how well the reactors have operated. A final, rather minor point but perhaps not so minor, is that workers in nuclear facilities are going to get sick like everybody else and they will be exposed to medical x-rays or other medical use of radiation. A subcommittee of the National Academy of Sciences has looked at the [237]
question of whether you need to take any further action with regard to such workers who have received radiation exposure from other sources.

Now here I might point out to the Board you again by the linear dose response hypothesis, because on that model there is no, you simply add another radiation source. Since the risk in proportion to that part of it is an accepted risk for the benefit of the individual, then there is no real legal issue at point here.

But if you are representing a non-linear response curve, then you clearly have a problem. Now I would like to just briefly summarize a few remarks about the environmental release from normal plants operation of nuclear reactors. This subject was gone over in considerable detail in the as low as practicable hearings and for this reason I don't think we need to dwell on this at great length.

But I would like again to come back to the point that the question of the reactor experience is commonly expressed in terms of such things as percent of permissible release. For a long time, as nearly as I can say, this was the major way in which the AEC at least transmitted the release rates to the Joint Committee on Atomic Energy, for example,

and in other words, percent of what they were allowed to put out.

No discussion of what they were allowed to put out [238] was a good idea or not. In large part, no discussion of whether in fact anybody verified that this is what had actually been put out.

The history of the reactor program indicates that things haven't always gone so well. For example, I just received a report of release of radioactivity in effluents from nuclear power plants for 1971 and if you look at these, you see at least for some of the plants, the rates are going up rather rapidly.

For example, at the Connecticut Yankee — excuse me. That is the Ginna plant of course the noble gas went up substantially in 1971, such that it is putting out 31,800 curies of noble gas. Whether this is a significant environmental impact or not depends on the stack height, but by and large PWR's have ground level release.

The point I am trying to make here is that if you look at the operating history you can see that there is a general trend upward. Where is this going to level off? We can't say. The number of new fuel charges have been relatively low, they have been highly variable in their leak rates and many of them are approaching the one percent design limitation.

So that the point I am trying to make here is, one, you cannot go from this to an estimate of what the reactor will be putting out at any particular time, or for a year in which they have a much higher operating experience [239] than is shown for 1971, which for its BWR's is around 60 percent operating and for PWR's around 75, give or take a couple. Depending on which reactor you include, so the ideal of

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course is to go from this to the environmental impact, if they were in fact operating at 90 percent capacity, which certainly the industry would like to do.

No where in these estimates are the potential health effects on populations within one mile, two miles, three miles, four miles, given. It would seem to me if we are concerned with the cost effects, environmental cost effects, there should be some efforts made. So with regard to fuel rates, fail fuel rates, I would say I have become somewhat more skeptical about the protestations of the industry that they will not operate plants at any fail fuel rates above say a tenth of a percent.

Another issue has to do with what happens with the plants we have now operating which cannot obviously meet the current as low as practicable standards. In the case of Dresden I, which is relatively small 200 megawatt leak capacity reactor, my estimates are that this, when operated at 90 percent capacity, will give a radiation dose approximately a mile or a mile and a half away in populated areas of about 75 millirems per year, clearly not meeting the as low as possible standards.

Now the question is what does AEC do about that?

[240]

No action whatever is being taken to retrofit that reactor with longer noble gas hold-up times, while at the same time Dresden II and III are being retrofitted. My question is why not Dresden I?

I am asking this question in part because I am curious to know what the AEC feels is binding with these as low as practicable standards. Apparently they feel it only applies to new reactor design. But what about the people who are living there now?

Another question that is important, which I have found difficult to pin down has to do with the extent to which there are leaks, either into the secondary coolant, in the case of PWR's frequently, or in turbine seals in both types of reactors. These usually bypass the clean up systems or have to have special ones installed.

With regards to the boiling water reactors, I would only say that the dilution characteristics of the stack effluents are a matter of considerable debate. For example at midwest fuel reprocessing plants, which will have a hundred meter stack like the Dresden reactor, the Department of Commerce, or Department of Interior, I am sorry, or EPA — wait a minute — the Department of Commerce evaluation of the release of radioactivity indicated that their calculations of the dilution ratios were substantially different from the applicants, which had been accepted by the AEC.

[241]

The AEC had accepted the applicants, by a factor of 3 not important of course if in fact the release will lead to small doses mabye, but it raises the question what about the dilution ratios for the Dresden plants, where it is important, where we already have this relatively high dose rate going out.

I had occasion last summer to be shown through the Dresden plant, Dresden I, II and III plants, and at that time the operators were proudly pointing out, it was a hot summer day, that all three plants were operating at 99 percent capacity. If I had asked the operators what is the radiation dose to the people in the environment, they would not have had the faintest idea. In fact I did ask them, there were discussions of how adequate their dosimetry was, and everybody agreed it was not very satisfactory.

The question for new plant siting is that the local meteorology is usually done very poorly and you cannot predict

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from these general models of meteorologic dilution what the radiation dose is going to be from an isotope release from a stack. This is true of nuclear reactions and also fossil fuel power plants. Finally, as far as the boiling water reactors are concerned, the isotopic mix of both noble gas and, of both crypton and xenon noble gas varies considerably.

This has been demonstrated by measurements carried [242] out by the Public Health Service and also by the company itself.

The fact that the isotopic mix varies so much mentions that you cannot go from a total curie release to a radiation dose to the population with a one to one core density. This induces another source of error in the estimates of the dose. With respect to pressurized water reactors, I would like to not say a great deal about this, except that I mentioned the gaseous release at least from some of the operating plants seem to be a lot higher than had originally been expected, and thus constitute a monitoring problem for the agencies concerned.

Also the question of the tritium release rates is not really usually a problem if you have plenty of water for cooling, but if you have a limited water cooling system, like a cooling pond, you may have difficulty in getting an adequate diffusion to the as low as practicable release rates that have now been announced by the AEC.

I personally think that they are actually unnecessarily restrictive, as I have already indicated. So in conclusion, as far as my reaction to the impact of power plants on the environment around them, it seems likely that the technology is available to contain these materials in a way which will not produce any significant public health problem to the people living around it, but the question is [243] how

are we going to know it is effective? What kind of monitoring program is being carried out on a large scale, and what evidence do we have as to whether there are some unforeseen problems.

[244]

I submit that the "as low as practicable" standards that the AEC has established will make it extremely difficult to know if anyone is meeting these standards or not.

Finally, I would like to say a few words about the problems of fuel reprocessing plants. Again my emphasis here is on what has been the experience, not what are we going to project into the future, what actually has happened rather than what do we hope is going to happen in the future.

The West Valley, New York plant is the only commercially operating reprocessing plant in the country and I think, as has been documented elsewhere, the releases of krypton have been about as expected, and the problem of krypton-85 doses from fuel reprocessing plants is essentially a skin dose problem. I will come back to that when we look at the other reprocessing plants.

Tritium, on the other hand, posed some different problems, and it is my understanding that the company itself, Nuclear Fuel Services, did not know how much tritium was going out in what form during a substantial part of the early experience of that plant. For one thing, the amount of tritium that remains in the cladding was underestimated so actually less was being released, but the question was how much was being released as hydrogen gas and how much as water, and that was not clear.

Surely before we embark on releases of tritium to [245] the environment — and there is currently no attempt being

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made to contain tritium at the fuel reprocessing plants, the technology is very much more difficult for tritium than for all of the other isotops perhaps. So before we embark on releasing tritium, we need a good deal more information on how tritium moves in the biosphere once it is released.

In other words, is there any significant buildup in the soil, et cetera, around the fuel reprocessing plants as a result of rainout, incorporation into the water and so on?

It is my understanding that the Midwest Fuel Reprocessing Plant will release tritium only at specified times, because they will avoid circumstances where the tritium fallout will be maximized in the local area. This is a good step, a step in the right direction. But how do you enforce that? How do you assure it happens? You just simply leave it to the company to say, "We will release tritium when we feel it is appropriate."

Can you leave it to them?

Now the Midwest Fuel Reprocessing Plant is kind of the same size as the West Valley Plant, a one-ton-a-day plant, and I have had occasion to go through that plant, through the courtesy of General Electric Company, and it is an engineering marvel, there is no question about it.

[246]

They propose to seal up the canyon in which all of the chemical processing will be done and from that instant on, no human touch will every be felt in that canyon. I respect the engineering expertise of the General Electric engineers, but this is a chemical engineering process the likes of which the world has never seen before.

So seal up an entire thing and continue it going for year after year, with only remote control services of the units, without any need to enter it, is a tremendous undertaking.

I take my hat off to them for even trying. But it apparently is necessary in order to be able to operate the plant.

Under those circumstances are we going to be able to guarantee that the containment ratios will exist all of the time, day in day out, as specified in their environmental impact statement? In particular, of course, one of the serious issues has to do with the actinide elements. These of course are in the form of plutonium, neptunium, curium and others will be present in relatively high curie activities. They will have to be contained since they are alpha emitters and these are among the most serious health problems if they emerge from the plant in particulate form.

Now it is not my contention that I can prove that they will not be, because I can't clearly. The experience in Savannah River and so on has been fairly good with the [247]
containment procedures they have used. But how good, how long, et cetera, are things for the future? They will have to be contained extremely well in the plant.

When we move to the Barnwell Plant, we see another pattern which I would like to comment on. Midwest Fuel Reprocessing Plant is about a half mile away from the Dresden reactors so that the radioactivity that is being released from the reactors will be added to the radioactivity released from the Fuel Processing Plant.

Now in talking to the General Electric people it is my understanding that economically it really doesn't help them a great deal to be that close to these reactors, even if they do process the reactor fuel. Since they have to store it on site anyway for a long period of time before processing, they have to package it for transportation exactly the same way as they would if they were sending it across the country, the way the San Onofre fuel will have to be, and there-

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fore the need to locate the plant next to the reactors is in no way clear to me, economically.

And what I submit has happened is that the choice was made as much because of convenience as anything else. That is, since the citizens in the vicinity of the reactors had already accepted the nuclear era, then give them some more because they don't really object to it much, and a little bit more won't hurt them.

[248]

Now I have tried to emphasize in the course of my presentation that a little more does hurt us, especially as you keep adding and adding. This idea of nuclear parks I think is a very serious mistake.

Now we have the Barnwell Plant, a five-ton-a-day plant, going up next to the Savannah River facilities, which have already extensively distributed radionuclides around the South Carolina countryside. My estimates of the skin dose from the krypton releases at Barnwell Plant are they will be in the order of 200 millirems per year, about a mile or mile and a half or at least beyond the border of the plants. I don't have a very clear estimate of the distances the prevailing winds, et cetera, and therefore this is not a firm number at this time, but it ought to be fairly close to this.

The difficulty with skin doses from radioactivity is that we have no really good estimate of risk. If you look in the BEIR Report, the question of skin cancer as induced by radioactivity is largely left unanswered. The reason is we simply have no data.

But it stands to reason that in accord with our understanding of our cancer inducing elements in the environment, that the presence of added ionizing radiation, in addition to ultraviolet radiation, which we already know is carcinogenic to the human skin, it would seem reasonable

to suspect there may well be a synergistic action between
[249]
ultraviolet and ionizing radiation.

So it may be that that 200 millirems per year, or whatever it ultimately proves to be, is not important, but it also may be important.

Note that my quarrel with the krypton releases is not on the global releases. I do think eventually the containment of krypton will have to be done, but I'm not concerned about the extent of contimination of the Northern Hemisphere atmosphere at this time. What I am concerned about is the people living downwind in the vicinity of both the Fuel Reprocessing Plant and the operating reactors.

Well, I will close my discussion at this point, since I think I have used up almost my allotted time, by simply pointing out throughout my discussion I have tried to emphasize that I can see at least three or four major areas of concern that have not been adequately addressed, and if they are adequately addressed in terms of the human health effects of nuclear power development, they definitely may change the economic picture, the plant siting picture, a number of these other pictures, operating expenses, et cetera.

If we translate all of these health concerns into economic trade-offs, that is building in better containment systems, cycling the workers in a different way, hiring more workers, if we can in other words solve them, in an economically viable way, then I would have no objection because you are
[250]
adding the true environmental costs of this type of industry where it should be added.

The question is will the industry have the foresight and determination to take those steps economically painful though they may be in order to provide an energy source in the future which will achieve its real goal.

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Thank you.

CHAIRMAN PAGLIN: Thank you, Dr. Radford.

Questions from the Board members? Dr. Steindler?

DR. STEINDLER: You presented a lot of material which obviously I would have to digest. I have made a few notes and they may seem somewhat disjointed to you, for which I apologize. They are somewhat random and perhaps some are pretty trivial.

You raised a question about not knowing whether it is triated hydrogen coming out the NFS stack or triated water. I'm sure we are both aware that that question has been resolved, because analyses are available.

The major issue that I would ask you about is why is it important? There is, after all, a very rapid exchange of the hydrogen into water, even if it is being emitted as hydrogen and the quantity of hydrogen we are talking about doesn't present an explosive hazard I presume, so where is that important?

DR. RADFORD: It is not of very major importance, [251]
Dr. Steindler. I only raised it because in some discussions some years ago with Mr. Runyon, who was at that time the director of the plant, I asked those questions and was not able to get answers.

The question of the rate at which the hydrogen would incorporate into other — exchange with other hydrogen sites might be some or there might be some differences. The diffusion rate of hydrogen is obviously different from water vapor, and it might depend on the relative humidity and so on.

I haven't worked out the kinetics of it and it may be a trivial issue.

DR. STEINDLER: I see.

You indicated there was a disagreement between the AEC and General Electric's stack dilution factor as calculated and the Department of Commerce I think it was as also calculated.

DR. RADFORD: Right.

DR. STEINDLER: Again I guess I have to ask a factor of three in an estimate of the stack dilution factors, using the windrose whose precision is poor, as you have indicated, why does that represent a significant point to you?

DR. RADFORD: Well, the significant point is that I think we all recognize that the dilution characteristics from the stack cannot be predicted better than a factor of [252] two, if that; in any rather special circumstances you can't detect it better than that.

The question I would ask is does this uncertainty ever appear in the final dose calculations? The answer is yes, always on the low side. In other words, the impression I have of the company's representatives is that they minimize the radiation dose by taking the maximum dilution characteristics. And when we have independent estimates of the dilution characteristics which would substantially increase the dose, these are I think quite significant.

[253]

DR. STEINDLER: Do you think we have available or do you have available a comparison between the actual experience at NFS, thereby, so to speak experimental stack, versus the various calculations that were prepared for NFS prior to actual operation?

DR. RADFORD: No, I have no such experience.

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DR. STEINDLER: I don't either. That seems to me that would be a pertinent experience factor to include in somebody's discussion.

DR. RADFORD: Well, it is true, it is worth pointing out, I didn't mention it, because Mr. Roisman had referred to, in the operation of the NFS, when it first went on line, they were not containing isotopes, the assumption being I-131 would have acknowledged to the point where it would be of negligible concern. It was found to be present, and I am not saying it was of major health significance, but the I-129 also went out and that is important. I have a statement from, in his case, EPA, which on page 146 of the environmental statement of the midwest fuel recovery plants it refers to the experience at NFS with regard to I-129.

I am not trying to make a case this is a major health hazard at this time, but with a 17 million half-life, this won't go away. In the case of the Middle West, specifically around the Chicago area, which is a goiter area, relatively low in cold iodine in the soil and in the bio, [254] therefore the addition of iodine 129 in significant amounts there would have a greater impact than in another part of the country which had a significantly high cold iodine level.

DR. STEINDLER: Are you suggesting, because you are citing that document, that the analysis of the iodine 129 problem that the staff has put in there is in error?

DR. RADFORD: The original containment, designed containment characteristics of the midwest fuel reprocessing plants were comment on by EPA and others and as a result they have changed the design characteristics.

Now all I am saying there is that isn't it a good thing that somebody besides AEC looked at it?

DR. STEINDLER: I think it is appropriate that I remain silent on that question. You indicated the potential of a synergistic effect between UV radiation and ionizing radiation. I think I have seen this comment before but I have not seen the slightest amount of evidence that there is such a thing.

Do you know of any evidence that would indicate that there is likely to be in fact a significant difference in the mechanism of action between UV and either high or low penetrating, energy penetrating radiation.

DR. RADFORD: There have been a substantial number of experiments carried out in cell cultures, things of this kind, of radiation effects, the UV and ionizing radiation. [255]
Whether it is any of these are germane to the issue of cancer, I am not in a position at this time to discuss, because it has been quite a while since I reviewed this literature.

However, it is generally recognized that if we follow the model of carcinogeneis that is current at this time, that it has something to do with a somatic mutation, then one can easily infer that the mutation induced by ultraviolate may be readily stressed by the fact that the ionizing radiation would interfere with the repair process. That is at least one defensible model.

Now, whether this has been looked at, experimentally, I just don't know. The problem I really raised was mainly that you cannot infer from Beir report, unfortunately, what the skin cancer problem is. It is one of the more common cancers, one of the least serious cancers, because it has a high cure rate, but nobody likes to get any kind of cancer. And in calculating the total cancer risk, it would be beneficial if we included the skin cancer component.

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None of these risk estimates I have made have it, but we don't know what it is. We know UV will induce skin cancer. But I am trying to emphasize the fact that the statement is made that krypton 85 is not a problem, because it affects only the skin tissues and everybody knows they have a higher permissible concentration of radiation dose allowed. I am not sure that allowed rad dose is substantially enough [256] based at this time to permit us to know whether that is acceptable or not.

DR. STEINDLER: Thank you.

CHAIRMAN PAGLIN: Dr. Geyer?

DR. GEYER: Dr. Radford, this question is asked simply because I didn't understand what you said.

Is it your feeling that the assumptions with respect to stack dilution characteristics used by AEC are not conservative?

DR. RADFORD: Yes, I would say that is the case, in some instances. Actually it is my understanding that by and large they accept the applicant's stack dilution characteristics. Usually, it seems to me anyway.

DR. GEYER: Maybe I better ask this question of the Staff.

MR. SMILEY: We don't really accept anything in this regard. We do our own checking and calculations. Generally the applicants with whom we deal feel we are anything but liberal. I think they consider us rather conservative in this regard.

DR. GEYER: Thank you.

This next question I guess also has to be addressed to the Staff, but it involves a matter that Dr. Radford brought

up. The Hanford chemical processing plants, if they are still in operation, have been going for quite a long time.

[257]

Could we be supplied with any information which shows the kinds of problems that occur in such plants?

MR. SMILEY: Are you referring to operating problems or are you talking about effluents or what?

DR. GEYER: These won't be the same exactly as the fuel reprocessing plants than being built for the commercial power industry, but they are not a lot different, I suppose.

MR. SMILEY: I must say I am not sure what is available in the open literature from the Hanford plants. I am sure environmental data from the outside is, but since they are Commission operated plants, I am not sure what is available on that.

Whatever can be supplied, we will give you, yes.

DR. GEYER: Since we have been talking about what experience shows, maybe we can find out here.

MR. SMILEY: I am not sure the experience would be comparable, but whatever is available, we can get it to you.

DR. GEYER: Thank you.

MR. SMILEY: One thing, Dr. Geyer, certainly all accidents are documented.

CHAIRMAN PAGLIN: Dr. Steindler?

DR. STEINDLER: One quick point here. You made the comment that I guess you were impressed by the GE plant and no one is going to enter the canyon and you raised the question about how, if nobody is there, we can insure [258] containment, I thought those were the words you used.

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Are you suggesting that inability to have access to the processing canyon per se lends question as to whether or not they will be able to meet the DF across their sand filler, for example, which as you well know is in a completely separate building 100 or 150 feet away from it?

DR. RADFORD: I am not that much of an expert on fuel reprocessing technology. But I am aware of the general design of the plants since they were kind enough to show me through it.

I was thinking of such things as the extraction ratio of say the stages that are carried out in the canyon, such as neptunium separation or plutonium separation, whether these will be achievable under conditions, day in and day out, where they have perhaps a delay in the length of time it will take before they can detect and correct failure of some components in the whole system.

DR. STEINDLER: You are raising an operating question then?

DR. RADFORD: Right.

DR. STEINDLER: Let me try and find out how that operating question, which I suspect the operator of that plant would consider an economic problem, how that particular operating question relates to the safety of either the people in the plant or the public at the outside of the plant when [259] you consider that there are specifications that are set, for example, for the product.

DR. RADFORD: Well —

DR. STEINDLER: I am trying to translate your concern into the environmental concern, if possible.

DR. RADFORD: First with regard to the operators of the plants, themselves, quite clearly if you have loss of

highly radioactive material in the canyon, you can definitely build up radiation doses, they have a very thick containment wall, but it is not infinite. So conceivably you could get a build-up that would affect the radiation dose to the operators, at least in some sites, for example, where the remote units go throught the wall.

The second issue is really one of time scale. That is, granted that the product that comes out is specified in terms of let's say purity of plutonium or what-have-you, it is conceivable, it seems to me — I am raising it as a question I suppose — that over the short run, and by that I mean a week, there might be breakdowns in the system which would have the capability of permitting a very much more substantial release to the containment filtering system, et cetera, than would have otherwise been expected, and even theoretically, a criticality accident. So that is the kind of concern that I am raising here.

DR. STEINDLER: I would simply say I think you [260]
have addressed yourself in that particular instance to points which not only the regulatory people, but also the operator of the plant have had to cover in detail as part of their operating safety concerns, and while this is not the place perhaps to explore this particular point, the environmental impact of what you indicate, the various problems you pose, I think are not quite as clear perhaps as you might indicate them to be.

That is all.

CHAIRMAN PAGLIN: Those are all of the questions from the Board, Dr. Radford. It looks like you will make your appointment with something to spare. We thank you, Dr. Radford.

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Mr. Roisman, do you have any further remarks from Dr. Radford?

MR. ROISMAN: No, but he will be here for the rest of the afternoon, so if something else comes up in the Board's mind, he will be available to answer them. If it should happen the Board has questions afterwards, we would be happy to have Dr. Radford address those in writing at a subsequent time.

As the Board knows, we will be submitting within the 30-day comment period written comments which will include the essence of what has been said here, and cover additional areas as well.

[261]

CHAIRMAN PAGLIN: I want to address myself to that at the conclusion of the presentation of your group. I would think in consideration of our very efficient reporter — she has been here all day — we should take a break now but only for five minutes.

(Recess.)

[262]

CHAIRMAN PAGLIN: May we come to order, please. Dr. Kendall.

MR. ROISMAN: Mr. Chairman, I was just going to announce that our last witness will be Dr. Henry W. Kendall who will discuss some of the areas —

CHAIRMAN PAGLIN: Excuse me. I beg your pardon. May I interrupt you, Mr. Roisman? Dr. Steindler has a quick question, one or two, for Dr. Radford.

DR. STEINDLER: I am sorry. I am concerned about the people who have to read this transcript. If I can ask the question this way — you indicated your four working

level months you calculate to be equivalent to, I thought you said, 20 rem per year. That differs from the National Academy report, and I am wondering whether that is based on your calculations or you have taken it out of here and I am misreading the report.

DR. RADFORD: You must be misreading the report, Dr. Steindler, because I wrote that section in the report.

DR. STEINDLER: I am perfectly willing to buy that.

DR. RADFORD: We used 5 rem per working level month, which did not significantly differ from the joint report issued by the National Institute of Occupational Safety and Health, and the National Institute of Environmental Health Sciences.

DR. STEINDLER: Were you suggesting — you made a comment that the contents of this report, the one I have
[263]
reference to is entitled "The Effects on Population of Exposure to Low Levels of Ionizing Radiation," the same one you talked about. Were you suggesting by an omission of the contents of the approaches that are used in this report, omission by the Staff in the analysis, that this is a fault which they should correct? In other words, are you suggesting that this is the kind of document that should be applied as a basic standard when providing for an environmental analysis?

DR. RADFORD: Right. Absolutely.

DR. STEINDLER: Thank you.

CHAIRMAN PAGLIN: Fine. Thank you, Dr. Steindler.

All right, Mr. Roisman.

MR. ROISMAN: The more I think about it, I think Dr. Kendall is a man who needs no introduction. Most of the

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people here have followed him in the emergency core cooling system hearings.

DR. KENDALL: My name is Henry W. Kendall. I am a nuclear high energy physicist, and a professor of physics at MIT.

Over the last now approaching two years I and associates in the Union of Concerned Scientists have been studying various aspects of the safety, safety assurances associated with the nuclear reactor program of the country. At the present time the Union of Concerned Scientists is in the midst of a study related to the subject of this hearing, [264] the nuclear fuel cycle.

I am going to speak today of three of the subjects of that study and there are others that I will discuss at the end of my testimony which will be included in the written presentation we make in a month.

What I wish to discuss bears very heavily on the potential environmental impact of nuclear reactors, and the associated apparatus for finding the fuel and disposing of the nuclear ashes.

These three subjects are: (1) the questions of catastrophic accident in nuclear reactor operation, its probability and its consequences, and a comparison with the assurances that have been made public by the reactor vendors, the AEC, and the utilities.

The second subject has to do with the diversion or possible diversion of what are called special nuclear materials. That is, uranium 235 or plutonium 239 from which nuclear weapons may be constructed.

The last subject has to do with the problems of the long-term storing of the very radioactive material as a

result of the fission of uranium in the power reactors under consideration.

Now in assessing the risk and the potential environmental impact of nuclear reactor operation, one has to do a number of things. One has to first assess the size and
[265]
scale of the kinds of an accident that is considered credible. One has to establish, second, the probability for the initiating events of such an accident. And third, one has to estimate the probabilities that the systems that are designed to contain or mitigate such an accident will or will not work.

This kind of a program is what one has to go through in order to establish the assurances of reactor safety. The size and scale of an accident of major proportions associated with a nuclear reactor are a consequence of the prodigious quantities of radioactivity that accumulate in these from the fragments of uranium that are a consequence of the fission of the original nucleii of uranium 235. The quantities in equilibrium operation for a reactor are numbered in the many billions of curies. Indeed in numerical notation, upwards of 10 to the 10th curies or more.

This includes material of short half-lifes, intermediate half-lifes, and some alpha active elements referred to as the transuranics, which are not fission products, incidentally, which have half-lifes in the order, some of them, of tens of thousands of years.

This fission product accumulation is equivalent to the fallout from thousands of Hiroshima-size nuclear weapons, and substantial attention has been paid to preventing the inadvertent release.

[266]

So what we are discussing is whether this substantial program is in fact adequate. 20 percent of these ma-

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terials are gaseous in normal circumstances, and if the material is released to the environment, in one or another way, at least the gaseous material will be swept along by the wind and expose people outside of the site boundary to what can be lethal amounts of radioactivity.

If a proportion of the fission product contents of a reactor are released which are of the order of 10 or 20 percent, passage of the radioactive cloud can prove lethal at many dozens of miles from the reactor site under particularly unfortunate, but not uncommon meteorological circumstances. The distances may approach 100 miles. And human health and injury and increased susceptibility to a variety of diseases can occur at hundreds of miles.

The AEC prepared in 1957 an analysis of the kinds of accident that might occur from such a release for a reactor size which is small compared to the reactors now coming on line. This was referred to as WASH-704, and is well known to many of us.

In 1967, there was a request to Brookhaven that this be updated in the light of the larger reactors then being designed. This full update was not carried out on the basis, according to my understanding, that there was no substantive change in the radiological consequences to the [267] core in the assumed range of meteorologies they considered, but there was only the update that was related to the increased size of the cores.

Our group has made its own update of WASH-704, with the results I have just briefly summarized. How does one prevent the release of this?

Uranium dioxide is clad in the zircaloy that forms the fuel roads. These in turn are mounted inside of the so-called pressure vessel which contains the hot water in one

reactor type, the steam for driving the turbines. This installation in turn is embedded in the containment, and perhaps in further buildings that are designed to form part of the defense system to prevent the release of activity.

However, the radioactive materials generate a great deal of heat, they cannot be turned off, and in the event of a pipe rupture or other kind of incident, it is possible that the cooling water would be lost.

If this cooling water is lost, and there is no emergency coolant restored to the reactor core, then a very rapid heat-up starts which after a period of a few minutes can no longer be cooled by emergency water.

The reactor core will proceed in unfortunate circumstances to melt down and the broaching of all manmade structures, and what appears to be the inevitable release of at least the gaseous components of the fission products.

[268]

The nature of this accident is not known in complete detail, but there is little controversy that uncontrolled meltdown would result in very serious circumstances and would present an unparalleled hazard to people at some distance from the plant.

Now the AEC has selected the kind of accident that they will consider as the maximum credible accident, and it is a pipe rupture of one of the recirculating lines in the reactor, and it is referred to as the design basis accident. The probability of such a rupture forms one of the links in safety assurance. The probability of such a rupture is referred to as highly unlikely or extremely remote.

Nevertheless, according to AEC sources, it is considered likely enough so that emergency systems are provided to reflood a reactor core or provide spray cooling to it in the

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event of a pipe rupture. Now we have to ask in viewing the chain of items that go to develop the assurance of reactor safety first what is the probability of having the kinds of rupture which could give rise to meltdown; and two, what is the possibility that the emergency systems will in fact fail to perform their function when they are called on.

There have been a variety of estimates and a variety of comments on the difficulty of estimating the occurrence of these pipe ruptures, but recently the AEC, in a document entitled "WASH-1250" has indicated that a major pipe [269]
rupture might occur as frequently as one in a thousand reactor years of operation.

This is not greatly dissimilar from a General Electric estimate applicable to their reactors. In the published estimations of probabilities in that document, the AEC further states that there is only one chance in a thousand that the emergency core cooling systems will in fact fail to function. The first important consequence from investigating this probability is that in our opinion it is not highly unlikely, in fact that is totally unacceptable. It is enormous.

This country has 150 reactors operating, under construction, or ordered. When these are all operating, we can expect on the basis of the AEC's stated probability to have one major pipe rupture approximately every seven years, and at the end of the century, when we have a thousand reactors, we will have one major pipe rupture every year.

This cannot by any measure be regarded as highly unlikely when looked at in terms of the entire inventory of reactors that is coming to be in this country.

Now the AEC, in considering that there is only one chance in a thousand, that given this accident, the emergency core cooling systems will fail to work, has not taken into account, in my opinion, the message inherent in the very lengthy transcript and document of records of the [270]
emergency core cooling hearings, which hearings very recently concluded.

In these hearings it was established that the majority of the nuclear reactor safety experts in the AEC's own contract safety laboratories, Aerojet Nuclear, Oak Ridge National Laboratory, and others, had substantial reservations about the assurances of proper operation of the emergency core cooling system.

In a letter from the Oak Ridge National Laboratory director of nuclear safety programs, William Cottrell, to the director of regulation on December 6, 1971, he stated for the experts in his group, "We are not certain that the interim criteria for emergency core cooling systems adopted by the AEC will, as stated in the Federal Register, provide reasonable assurance that such systems will be effective in the unlikely events of a loss-of-coolant accident."

D. L. Hobson and P. L. Rittenhouse wrote a letter to Horace Rosen of the Regulatory Staff on March 1, 1971, and stated, "We believe that there is a consensus that what might occur during a major loss-of-coolant accident is still open to question."

George Lawson, heat transfer expert from Oak Ridge, stated on March 1 of last year, "Any conclusions with respect to the effectiveness of emergency core cooling systems is speculative."

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[271]

Norman Lawben of the AEC Regulatory Staff in February 10 last year stated, "It is possible for certain accidents which now calculate a temperature of 2300 degrees F, that the cladding temperature calculation could reach melting."

Cottrell also stated in the Oak Ridge National Laboratory nuclear safety program annual information meeting, February 16, 1971, that in view of results that his laboratory had obtained in studying fuel rod swelling and damage which aggravated the course of an accident, that he believed it was doubtful the emergency core cooling could work.

Finally, Milton Shaw, in a letter to the general manager of the Atomic Energy Commission, G. M. Cavanaugh, in February, 1971, stated, "No assurance is yet available that emergency cooling can be delivered at the rates intended and in the time period prior to clad and subsequent fuel melting due to decay heat generation."

In view of these statements and of many more that are in the transcript of the emergency core cooling system hearing, it is apparent that the contention that the emergency core cooling system will work, 999 times out of 1,000, has no factual basis and in fact our own study has indicated that in fact the margins of safety that these systems provide have in some cases vanished entirely, and that there are certain accidents associated with pipe rupture for which these systems [272] will not work.

It is a reasonable conclusion from this analysis that within some number of years, which cannot be precisely specified, but which is very likely fairly short, that is of the order of 10, that there may well be a catastrophic release of radioactivity from an operating nuclear power reactor.

This is based on the Atomic Energy Commission stated probability of a pipe break. This probability neglects

other events which are not considered in forming the number. Pressure vessel rupture, which has not been shown to be impossible, operator error, and other presently undefined events. That could be heat cropping up — for those of you who are familiar with the field, I would mention fuel densification, the difficulties presented by certain small pipe ruptures, ruptures of steam pipes, and other things of this nature. So the likelihood of major release which I stated could very well be a substantial underestaimte of the rate at which these may occur.

The chance of the initiating events is totally unacceptable. There are a class of accidents for which the emergency core cooling systems as presently designed are in principle of no effect and are worthless. Pressure vessel rupture is one such.

It has been brought forward in the hearings **[273]** concerning the Maguire reactor by Professor Whitlaw that the bolts which hold down the main pressure vessel cover could in an unfortunate circumstance rupture, allowing the entire cover to be released and projected vertically upwards at some 200 miles an hour, carring away all manmade structures vertically, leaving the reactor internals open to the sky, and taking the control rods with it.

A preliminary estimate that he made of the probability of this was one in a thousand. There are apparently a number of reactors, Kewaunee, Prairie Island, possibly Surrey, for which the placement of the steam lines is unacceptable.

In the first two named reactors, the steam line passes underneath the auxiliary building, outside the principal reactor containments, and a rupture in that position would

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disable all of the emergency equipment and leave the reactor with no residual core heat removal capability.

It also passes under the control room where a rupture would destroy the control room and kill the plant operators.

There are many unassessed effects or incompletely assessed effects that aggravate loss-of-coolant accidents. Radioactive heating has been underestimated. Secondary steam turbogenerator failure in reactors, which occurs normally in small amounts, has been shown to be able to defeat
[274]
entirely the reflooding capability that is required to mitigate a loss-of-coolant accident in a pressurized water reactor. And flow blockage arising from fuel damage which was the phenomena that occasioned Mr. Cottrell's comment that he doubted if the emergency systems would work.

The links in the chain of assurances of reactor safety, in our opinion, based on a deep study of these matters and an involvement in the emergency core cooling system, the links are all defective, and the assurances of reactor safety are not what they are stated to be, but in fact are missing.

The consequence of this is there is a failure to provide protection in the event of a peacetime accident of unparalleled scale and consequences. The matters that I have discussed here, like the matters that Dr. Radford has discussed, in some measure have been disallowed in every hearing that I have heretofore been associated with. Taking in the aggregate these have to be considered in the environmental impact of nuclear reactors. The risk evaluations, the estimations of probability, the accident records, and the entire chain has to be made open for public review and scientific evaluation by groups such as our own, in order that errors of the kind that I have here identified shall be surely identified in all cases, and so that we will not

develop large numbers of reactors with the flaws that we now [275] see. The risk-benefit calculation which has been made somewhere has been a risk bestowed upon people other than those who made the decisions, particularly the general population, who have had the greatest difficulty in becoming informed on these matters.

The second subject I wish to discuss has to do with the materials, uranium 235 and plutonium 239, from which nuclear weapons may be fabricated. There are a variety of reasons why groups or nations might wish to acquire nuclear material, and many of these are familiar to use. Except for a large, well-equipped industrial nation, the chief obstacle to making a nuclear weapon is in obtaining the material.
[276]

Uranium-235 is separated to the required concentration from naturally occurring uranium with only the greatest of difficulty, and plutonium is made artificially in nuclear reactors. In obtaining the material, then, diversion of someone else's supply can be a very attractive, inexpensive means, and in some circumstances it can be conducted in a clandestine way, and the ultimate possessor may not be identified.

Who would want this? There are nations who might, where even a modest nuclear capability, a handful of weapons and so forth, could set the stage for nuclear blackmail of non-nuclear powers.

It is impossible to assess precisely the security risk that this would present, and the risk to world peace. But it certainly is clear that it is a serious potential threat.

There are smaller groups than nations, but groups still with some kinds of resources behind them, perhaps major

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resources, who might want this material. And in recent years it has become clear that such groups exist and could well wish to acquire it, groups such as Black September, possibly the Weathermen, and others.

This can be used for nuclear blackmail or possibly with the alpha emitters for a kind of radiological blackmail, which has not been well documented.
[277]

The materials are, of course, also extremely valuable, and many experts have suggested that a black market worldwide could prove possible.

Ralph F. Lumb, who carried out an important study in 1966 for the Atomic Energy Commission on the subject of safeguards to plutonium and uranium-235 stated in AEC document WASH-1076:

"It seems inevitable that a world market in special nuclear materials will develop, and with such a market we can expect developments of a black market and attempts for terrorist and insurrectionist groups to turn these materials for their own purposes."

And even more authoritative warning was imposed by AEC Commissioner Clarence Larson in the Los Alamos Safeguards Conference in 1969, who stated that:

"Once special nuclear material is successfully stolen in small and possibly economically acceptable quantities, a supply stimulated market for such illicit materials is bound to develop, and such a market would surely be expected to grow once a source of supply has been identified. As the market grows the number and size of thefts can be expected to grow with it. And I fear such growth to be extremely rapid once it begins.

"Such a threat would quickly lead to serious [278] economic burdens to the industry and a threat to national security."

It needs no emphasis to add to those remarks that this is a critical and important problem. Unhappily the record of safeguards of these materials in our society has so far not been entirely satisfactory. There has been considerable effort and some resources devoted by the Atomic Energy Commission to the question particularly of safeguarding these materials while in the processing plants by methods of accountability, inventory, development of analytical and assay techniques and other things of this kind.

However, there has not been an equivalent emphasis on the weaknesses in the transport of these two hazardous elements. Special nuclear materials for military purposes are treated differently in transport from materials for peaceful purposes. And the guarding of shipments designed for peaceful purposes is much less stringent and much less well carried out than for the military case. Indeed, Brigadier General D. L. Crowson, who was head of the Atomic Energy Commission Office of Safeguards and Materials Management noted that the strategic nuclear materials destined for civilian purposes are usually shipped like a special delivery letter. And there have been a number of examples where quantities of material equivalents to a number of nuclear weapons have been inadvertently diverted in transit [279] and temporarily lost.

There have been other cases in which plutonium has apparently disappeared. In a recent article in SCIENCE it noted a 1969 SEFOR reactor which was deficient in a few kilograms of plutonium. And the Nuclear Materials Enrichment Corporation in person noted that over six years

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the strategic materials had a 6 percent which was unaccounted for.

Now the impact of the fuel cycle must contain matter contingent on diversion of strategic materials, because the projected growth in the amounts of these in the society and the increasing ease with which these may be fabricated into nuclear weapons, as the technical problems and their solutions become more widely known, is generating an increasingly grave problem for us.

You will recall it only requires 5 kilograms of plutonium to insure a critical mass, and approximately 20 kilograms of uranium-235. And while there have been expressed problems with the possibly difficulties of fabricating weapons using plutonium produced in civilian reactors, which has a substantially larger amount of plutonium-240 in it than weapons-grade plutonium, it is by no means clear that the civilian reactor produced plutonium is ineffective in making a nuclear weapon.

The projections are that in the period toward the **[280]** end of this decade we will be accumulating plutonium in amounts typically 10 to 25 thousand kilograms per year, and a very small quantity of this diverted to the black market would be adequate to allow the kind of terrorist activities which we want no part of.

The aggravation of this situation when and if the breeder reactors are in wide deployment would be very great, because the breeder uses weapons-grade material in large amounts, and this increases the amount in the system somewhere, and being transported.

The weaknesses in the transportation system have, like the consequences of diversion, been noted by a number of experts. In a paper presented at the International Confer-

ence of the Atomic Industrial Forum and the American Nuclear Society recently, November 1972, Mason Wilrich from the University of Pennsylvania stated:

"The U.S. national safeguards system which should include effective measures for physical protection and recovery, as well as accountability, is still primitive. Under existing regulations, for example, it is possible that a large amount of special nuclear material may be stored in a locked building that is checked by an unarmed watchman only once every four hours.

"In the shipment of a large amount of [281] special nuclear material by truck, the driver is not required to be accompanied by someone else, nor armed, nor even in continuous communication with any authority.

"Moreover, there are no regulations in effect which specify procedures for the recovery of stolen material."

He goes on later in the paper to say:

"Lacking an over-all rationale, the U.S. national safeguards system is embodied in a patchwork of AEC regulations and the ad hoc arrangements with particular licensees and contractors, lacking a single focus of responsibility with policy or control activities amied at preventing nuclear diversion. It is doubtful that the Commission can either develop or implement a systematic approach to the problem. The AEC cannot expect industry to cope effectively with its side of the nuclear material control problem unless it specifies clearcut objectives and detailed procedures and comprehensive regulations."

There is apparently no projected increase in the money that is slated to go into these activities in the AEC, inspite of the projected very great increase in the amount of ma-

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terials which the system will have to deal with in the near [282] future.

We have, in the course of our study of this, and I should emphasize that it is still in course, verified the bulk of what Mr. Wilrich has stated. And it is our belief that the safeguards, particularly with transportation, but elsewhere, too, have not had the priority that they deserve. They are apparently not projected to have the funding and resources which we believe they deserve. And although there are now projected improvements in some of the transportation safeguards, it remains to be seen whether these will be put into effect so as to provide adequate security.

There are many other persons who evidently agree with our assessment of these weaknesses. The Deputy Director of the Office of Hazardous Materials of the Department of Transportation has stated he felt it was his duty — I will read the quote.

> "I feel it is my duty to alert you to the fact that the protection systems on which a great deal of reliance is apparently going to be placed by the AEC are not as reliable as you might think."

The Institute of Nuclear Materials Management, in May of 1970, stated that the situation with respect to transportation is "unpalatable."

These matters must not be deferred, they have to be dealth with with the kind and level of concern that is [283] commensurate with the possible hazard of a successful diversion.

In particular, we require a vastly improved physical security for all transport and storage, the kind and nature

of the shipments has to be viewed in light of possibly successful diversion attempts.

There has to be a substantial commitment to establish the risks and the probability of diversion and to select and to develop the kind of improvements that are required.

The last subject has to do with the long-term storage of the radioactive materials that are produced during normal nuclear power reactor operation.

In many of the publications that have outlined the nature of these problems, it has not been made clear that there are two components to the radioactive wastes. These have been mentioned earlier by Dr. Radford, and I would reiterate that there are fission products whose principal difficula components are cesium-137 and strontium-90, which have half-lives a bit shorter than thirty years, and which after a number of years' storage come to dominate the fission product material.

Storage of these materials alone requires times in the many hundreds of years, perhaps a thousand years or so, before they decay away to essentially innocuous levels.

[284]

Included in these wastes normally, however, are the so-called alpha emitters, also referred to as the transuranics, many of whose half-lives are in the tens of thousands of years, and plutonium with its 24,000-year half life is one particularly noxious example.

These materials have to be given storage of almost geological time spans, that is, hundreds of thousands of years. The quantities of these are lesser by some substantial amount than the fission products themselves. And so far the separation which would be desirable has not been proven to be technically possible. But it is a prospect on which

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substantial importance in our opinion should be attached, because the short-lived materials can be put in different kinds of repositories than the longer alpha emitting materials.

The problem of storage and its effect on the environment has to be viewed in terms of the record to date to deal with this increasingly aggravated situation. Waste storage was accomplished in Idaho for some materials until the National Academy of Science, National Research Council report indicated the weaknesses that were inherent in that and the material had to be dug up and removed.

Lyon, Kansas has proven an embarrassment of substantial degree to the participants in it, where 100 million dollars was spent over fifteen years to develop salt bed [285] disposal of the materials, following which, in 1971, the AEC announced its request for $25 million to establish a National Radioactive Waste Depository.

A number of groups were highly critical of this, professional groups, and it was proved ultimately that the site was not, as had been claimed, adequate for the storage of these materials, but, in fact, was notably inadequate.

In the words of the Director of the Kansas Geological Survey, writing in *Technology Review* in March 1972:

> "In other words, the Lyons site is a bit like a piece of Swiss cheese, and the possibility for entrance and circulation of fluid is great. Other investigations revealed approximately 400 feet of displacement in arbuckle rocks, suggesting the presence of a major fault."

All of these facts have led the Kansas Geological Survey to recommend that the Lyons site be abandoned. [286]

An independent analysis by a committee of the Kansas Geological Society produced similar conclusions, as did the analysis of the Council of the Kansas Academy of Science. He went on to comment on the whole general concept, and stated:

> "As to the general concept of burial of nuclear wastes in salt, the jury is still out. Appropriate studies should reveal whether or not radiographic wastes can be stored safely in salt."

So that we are still left, as has been stated earlier here in testimony, with accumulating amounts of this and nothing but temporary storage. Is the temporary storage adequate? It cannot at this time in my opinion be so stated with adequate assurance. And there seems to be some difficulty among the experts as to how good and for how long the temporary storage which is not yet fully designed will in fact work.

Mr. Pitman, Mr. Frank K. Pitman, Director of the Division of the AEC Waste Management and Transportation, in a paper at MIT last July stated:

> "It is expected that even with nominal maintenance, the structures could be maintained in serviceable condition for many hundreds of years."

I believe that he made an equivalent statement today in reference to temporary storage structures.

The Assistant General Manager for Environment and [287]
Safety of the AEC, in the journal "Nuclear Industry" last December stated a somewhat different conclusion:

> "Use of man-made engineered storage assures that there is a safe solution to the high level waste problem for many tens of years and possibly several centuries."

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So we cannot be completely sure in fact that these things will be good for many hundreds of years or that one will not be faced sooner than one thinks with the juggling of these materials. In our opinion the question has never been adequately explored of the legacy that we are developing for future generations for tens or perhaps hundreds of thousands of years of material to be handed down to our progeny.

And that deserves a much more thoughtful and careful look than it has so far gotten. In doing this, it seems to us appropriate to solve the disposal and/or storage problem as it exists and not take advantage of temporary, possibly inadequate techniques, and hand this off to someone else. It is a new kind of risk-benefit calculation which allows us to gain the benefits now and hand the risks to people who are yet unborn, to hand the storage problem to a society which may or may not be able to continue to assure the safety of materials from which they will gain no benefit whatever.

In concluding this report, delivered in the midst of our study, pursuant to the subject of this hearing, I would [288] just like to emphasize again that on all questions of environmental impact, of man's options, and in particular options that are associated with radioactivity and nuclear fission, one has to inspect the prospects in the view of recent history and recent experience, which unfortunately has not always been as satisfactory as many of us would have liked to hve seen.

The question really is should one lay out the plans and carry out the projects on the basis of things as they would hopefully be, or as they are likely to be? And there is a very substantial divergence between these two concepts and

one cannot look at the program, in my opinion, through rosey glasses following a thorough inspection of what has passed recently.

Thank you.

CHAIRMAN PAGLIN: Thank you, Dr. Kendall.

Questioning by the Board.

Dr. Steindler?

DR. STEINDLER: Dr. Kendall, could you describe in a very few words how you view the relationship between the review of the ECCS and the reactor accident in relation to the documents we have on the fuel cycle, which excludes completely the reactor *per se*?

DR. KENDALL: It is our opinion that it is a most important matter in looking at the environmental impact of the [289] fuel cycle to look at the whole fuel cycle. And I'm in the position of Dr. Radford of having tried to raise some of the issues I have described today in the individual plant circumstances and in the energency core cooling system hearings and I have been unsuccessful.

There is nothing that is more useful to groups like ours and I believe both to the AEC and to the reactor industry than to see these matters all laid out together in a coherent form and with a careful synoptic view. And we are taking that position in the preparation of our written material and I have taken that view today because the reactor program cannot be investigated through a microscope, one piece at a time, because the impact of the one-thousandth plant can be little more than one-tenth of one percent of the impact of the program.

And investigating the chance of an accident will show very easily that what might be an acceptable probability

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for a single reactor can very well not be acceptable when you have a hundred or when you have a thousand and I feel that it has been a defect in the particular environmental statement that we are discussing today that the entire fuel cycle has in fact not been studied in this way.

Mr. Roisman would like to add I think to that.

MR. ROISMAN: Doctor, I guess in a sense it is basically a legal question as well. It is our judgment and you [290]
may notice that other participants here have suggested in written comments their feeling that there should be a generic approach to problems which are generic, site related problems of nuclear power plants are properly handled at the site, but the question that we see as being involved in the environmental fuel cycle is let's remove from those individual licensing proceedings the duplication that would occur, those environmental impacts which are generic and treat them as a single document.

As you know we suggest that that document must be prepared in the context of an ajudicatory, generic hearing, but you would then have an important part of the cost-benefit analysis that has to be done in deciding whether or not to license a particular power plant. You would have some feel for all of the generic questions.

We have been foreclosed time and time again to talk about questions like risk probability and the consequences of reactor pressure vessel rupture, the likelihood of that event, or hamstrung by narrow interpretations of our rights.

This document should be, could have been but is not, a document that deals with that. The thrust of much of our presentation today is to suggest what we think the proper

scope, as well as the proper procedures should be in connection with this. So it is in our opinion a flaw in the document.

[291]

Obviously there is nothing relating to these subjects in it, in fact accident analysis at almost any phase of the fuel cycle is treated cavalierly, to say the least, in our opinion. And much of what Dr. Kendall has said about the emergency core cooling system experience we think is teaching for the question of whether or not accident analyses that appear in this document and relate to other parts of the fuel cycle shouldn't also be substantially more thoroughly investigated.

There is a long-term lease on in the ECCS experience and that is that an agency that has as much invested in nuclear power promotion is unwilling to talk about the bad side of the story.

Now an environmental impact statement of course, an environmental report, would have to include that. Part of our presentation is to attempt to open up the questions, not answer them all.

DR. STEINDLER: Fine, I would have hoped that in light of your approach to the question of accident analysis you could have addressed yourself either now or subsequently in great detail to the shortcomings of the accident analysis as you read it in that document. I am assuming that on the basis of your interest in those analyses, you will do so at some time in the future.

Let me ask a few other questions of Dr. Kendall.

[292]

Are you suggesting that because weapons have been made out of 93 percent enriched U-235 that the three to

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five percent 235 fuel material that is used in reactors represents a weapons risk?

DR. KENDALL: It perhaps represents a tiny risk.
[293]

I was not suggesting that it represents a risk as important as the transport of weapons-grade 90 percent enriched, which I would note is used in high temperature gas cooled reactors of which there have been six or eight already sold, with one coming on stream imminently.

How a reactor of that kind, which may figure prominently in the National Power Reactor Program, and which topic was not discussed in the Environmental Survey of the Nuclear Fuel Cycle, a reactor of that kind contains two tons of weapons-grade uranium-235. So to that extent it could figure in an important way in diversions.

DR. STEINDLER: So your comment on uranium was a generic comment in a sense, then?

DR. KENDALL: I believe so. I believe in that sense it was.

But I was particularly referring to shipments of the weapons-grade and, of course, plutonium.

DR. STEINDLER: The shipments of plutonium that you referred to I presume are not the once that are currently going on, since I gather from the discussion I think this morning or earlier this afternoon, that plutonium as such is currently being stored.

To what extent do you, then, consider shipment of plutonium as a risk item?

DR. KENDALL: I wasn't in the audience during the
[294]
time of the earlier discussions, so I can't base my answer on knowledge of that.

But there is now application to use plutonium in operating reactors in the country, in particular Vermont Yankee, which is to use plutonium rods. So that this becomes now part of the normal transportation of fuel.

DR. STEINDLER: So that also, of course, I think you know, is excluded by specific design from the uranium fuel cycle we are talking about.

I am trying to focus in on the pertinence of what you have said to us, and which obviously the Commission is going to read, since that is the funciton of this whole thing, in relation to our documents here.

DR. KENDALL: The title of the document is "Environmental Survey of the Nuclear Fuel Cycle," and the use of plutonium certainly is encompassed in that subject and title.

And the plutonium, of course, is developed, is made in reactors, which are fueled with uranium, and it is a part of the material which is separated out in the fuel reprocessing plants.

MR. ROISMAN: Excuse me; but with regard to that last question, I think we should make it clear it is not our intent to be bound by the Commission's attempt to unnecessarily narrow its view of what the environmental effects of
[295]
the nuclear fuel cycle are.

CHAIRMAN PAGLIN: You say, Mr. Roisman, you are not going to be bound by the Notice of Rule Making?

MR. ROISMAN: No. I am not going to be bound by what the Regulatory Staff put in the yellow documents. The Notice of Hearing said we were going to be discussing the wisdom of taking several different legal courses of action. We suggest that thw wisdom of that action is suspect

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because it is based upon a document which doesn't talk about many of the most important problem.

But it should not be surprising that we are in great conflict with the Staff on this. You have heard what we have to say today, you have heard what they have to say. We think they are talking about the wrong problems in many cases.

Obviously the thrust of our presentation is, Let's start talking about what people ought to be concerned with.

We are bothered by the Commission's unwillingness to talk about anything other than the so-called good news, without talking about the waste.

We hope when the Commission reviews our fuel cycle report and our statements on the record today they will think again about whether they should accept the Staff's very narrow concept — I think, Doctor, you pointed out the title of the document is deceptive, they say in the beginning, We [296] are excluding this or that. And we are saying that's wrong. You should not have excluded those things.

DR. STEINDLER: To get back to a technical subject where I feel more at home: Dr. Kendall, are you suggesting by your discussion on the problems with long term disposal of waste that the environmental impact of wastes as being part of the fuel cycle should not be considered until a solution is available to their ultimate disposal which is sufficient for all time?

DR. KENDALL: I have a little trouble hearing. I am going to get the question from Mr. Roisman.

CHAIRMAN PAGLIN: Be sure you get it the same way.

MR. ROISMAN: To avoid any Russian gossip problem, Mr. Chairman —

CHAIRMAN PAGLIN: I was just twitting Mr. Roisman.

MR. ROISMAN: I knew you were twitting Mr. Roisman.

Doctor, if you wouldn't mind repeating the question a little more loudly. Dr. Kendall does have a hearing problem. And your microphone is on, but it is fairly far away.

[297]

DR. STEINDLER: Let me try once more. Perhaps to simplify the thing, what I thought I heard you say was that there really isn't any point in considering the disposal of wastes as part of the environmental impact until you have a procedure available to you that will solve the problem of ultimate disposal for all times. Is that what you meant or am I interpreting something wrong?

DR. KENDALL: It is not what I meant, Dr. Steindler. I think it is critically important to survey all of the ramifications. The AEC has decided recently, indeed, it has backtracked recently to focusing on temporary storage and its environmental impact should include a detailed and deep review of the implications of this backtracking, because the temporary storage was initially rejected as a consequence of the required surveillance of the material. What we are asking for in this and other areas, are complete and in-depth reviews of all of the alternatives, including the commitments to search for adequate really long-time disposal methods which would not present a hazard either at the present time or over the entire life of these noxious materials.

DR. STEINDLER: You don't consider it as an acceptable practice to store high level wastes under surveillance for a prolonged period. Is that correct?

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DR. KENDALL: There is a tendency which has been noted in reports that the backtracking to temporary storage, which [298] in my mind is not really acceptable and would not be if we had an adequate permanent disposal for the material, is not wholly safe in my opinion. These materials have the potential for widespread contamination, and major portions of the oceans or land mass could be contaminated in an inadvertent release, and the temporary storage to my mind, is really not safe.

And when the AEC believed that it could successfully store in Lyons, Kansas, it abandoned temporary storage because of the surveillance required. There should be a heavy commitment to finding a place for this, and if no place can be found for it, then the program that generates it should be reevaluated, in my opinion, and the material has to be thought out, perhaps through the route of detailed examination, in connection with the environmental impact study of the waste material itself.

DR. STEINDLER: One more question, I don't want to belabor the problem of wastes, but do you, if given the question of choice, would you prefer "permanent disposal" with some unknown far into the future risk, versus, what you call temporary storage with a string attached to the wastes in a recoverable form with the appropriate kinds of assurances you heard given this morning — you weren't here — that you would have heard if you had been here, which doesn't help much.

[299]

DR. KENDALL: In my opinion, there is not at the present time enough information available either to me or to the people who have presently these problems and have responsibility for these problems, to decide that matter adequately. I think it requires a further commitment to

research and study before that can be adequately answered. We do not know whether there are places deep in the earth where this material can be placed where it could be assured at some level of adequacy that it would never again interfere with human activities.

If someone could demonstrate to me that, for example, you could store it at the bottom of a 10-mile deep hole and close the channel and that the materials had no appreciable chance over the times required of returning to the surface, then I would prefer that.

DR. STEINDLER: So would I. I think so would everyone. I guess what I am asking is, short of those assurances which I think we both appreciate are somewhat hard to come by, you still do not choose what you call temporary storage of the kind I hear the Commission moving to.

DR. KENDALL: There seems to be no alternative at present to temporary storage, because the issues have not been resolved. There has not been an adequate and diligent search to establish whether the 10-mile hole, for example, is feasible. Dr. Schlesinger announced sometime ago that they [300] were studying the possibility of rocketing the wastes into the sun. Whether or not this is a visionary scheme, it is surely agreed by everyone, I think, that it is not presently practical. And a scheme like that, if it worked, would be fine and I can't give you an informed and thoughtful opinion in the absence of adequate body of technical information.

It is desirable to have happen just what you stated, namely, to have the materials permanently out of sight and with no possibility of their return. And what is required is a diligent application to search for these technical solutions.

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I think if these solutions are not forthcoming, then the program should be reevaluated, that is, giving rise to the radioactive wastes, namely, the nuclear reactor program. You can't operate if you don't know what you are doing and that is not the situation at present. I am uneasy with the above-ground storage for the same reasons AEC was originally uneasy with it. And they are stuck with it, because Lyons, Kansas, was a major fiasco, frankly, and they were forced back to it.

Now what will become of this, I don't know. But it needs further study.

CHAIRMAN PAGLIN: I have just one question, not n a technical basis, I can assure you, but I want to have specific references to Dr. Kendall's remarks, with regard to
[301]
nuclear blackmail and the potential terrorist activities. What I am a little puzzled about is its relevance in terms of the subject of this particular rule making, however, you may not wish to have it so restricted. The subject of this rule making, as I read the notice, has to do with the enviornmental effects of the particular licensing having to do with the economic, technical or other effects as against the benefits of the facility. I say this with all due respect, Dr. Kendall: I guess those words are exciting reading in newspapers, but I would like to have your statement, when you finally file it, indicate the relevance between the responsibilities of the Atomic Energy Commission under the National Environmental Protection Act in these respects as against, at least, what I read to be the subject matter of your comments in this particular wise, and that is the military and potential security aspects of the transportation of nuclear materials.

Do I make myself clear?

MR. ROISMAN: Yes, Mr. Chairman. Again, let me emphasize that our purpose, the objective of both organizations, is a thorough analysis of what is involved when the country continues to develop fission nuclear power so a judgment can be made.

Now, we see this as an opportunity to have that discussion. I don't think there is much doubt, however, that [302] the National Environmental Policy Act is the act under which it would be perfectly permissible to demand a review of the questions of terrorist diversion. That is an activity which is classifiable, if you will, in the same as an accident or quality assurance, both of which are subjects in individual licensing proceedings, when we talk about the accident happening or a poor quality assurance program.

The act itself is based on the premise that we will try to find what are the possible environmental impacts, and those impacts have included not merely the simplistic questions that we initially thought about in terms of the environment, that is, how many fish will get hurt, but what is the effect going to be.

If the shipment of weapons grade material is tied into the nuclear fuel cycle, in the development of nuclear power plants, if that shipment is subject to diversion and we can see a rational chain of events — I think Dr. Kendall more than adequately substantiated that rational chain — then we have to ask the question, given what our present methods are for controlling that diversion, what kinds of risks are we dealing with.

I mean the reason pipes break in plants are to some extent because of quality assurance, somebody screwed up somewhere and the pipe got weak at the wrong place and wrong time and there was a break. Now, we are talking

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about a break [303] of a different kind, a break in the chain of shipment or storage of weapons grade material and that, too, has a consequence that is predictable, that is it will get into the hands of somebody who shouldn't have it, then will use it in an irresponsible way.

While it may be difficult to scope that impact, you can imagine several different scenarios, it doesn't back away from the impossible, it only says do what you can, do the fullest extent possible, as the language in Section 102 states.

CHAIRMAN PAGLIN: You see then, forgive me for using the word, a fusion somehow between what is known as, I understand, the impact on the environment as against the political and military security?

MR. ROISMAN: Of course, what is precisely involved in political and military security is that someone threatens to do a heck of a lot of damage to the environment in exchange for something they want. And that is a pretty high risk, depending upon who you think is going to make the decision and how stable you think the people who have their hands on the thing.

CHAIRMAN PAGLIN: That clarifies it in a more generalized sense than did Dr. Kendall.

MR. ROISMAN: Dr. Kendal may want to say something with regard to this also.

[304]

CHAIRMAN PAGLIN: You understand reasonable men may differ on that interpretation, nevertheless.

MR. ROISMAN: I am perfectly well-aware of that. I think reasonable men may have an opportunity to differ in the not too distant future in a forum where we will all know who is right.

DR. KENDALL: I would add to that, if the whole question of diversion and terrorism were restricted wholly to blackmail which was successful, then there would perhaps be a very low probability of their being environmental effects. But much of what we consider now in regard to terrorism has to do with outright acts of violence, and we consider it possible, perhaps likely, but possible, that the diversion of nuclear material, would, in fact, lead to a radiological event of some kind, using the materials as radiological weapons, a matter which has not been much explored, or actually constructuring and detonating a nuclear weapon.

To this extent, of course, the impact on the environment can be very substantial.

MR. ROISMAN: Mr. Chairman, my colleague has also brought to my attention a case on the subject which may be instructive. I see it is contained on page 6 of the documents submitted by Babcock and Wilcox. And the case is Handley vs. Mitchell, which involved the question of the environmental [305] impact associated with, among other things, the construction of a jail in a particular community. And the court rules there that the possibility of a riot at the jail would have an impact on the communities in which the jail was associated and that, therefore, was an appropriate matter to be considered under the National Environmental Policy Act in judging whether to put the jail at that particular location. I think that is fairly close to Dr. Kendall's comments with regard to terrorist activity in general.

CHAIRMAN PAGLIN: I won't pursue it at this stage; I think it should be handled in the written documents. I have been advised that the Regulatory Staff has some timing problems with respect to their transportation. Were you going to say something about that, Mr. Murray?

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[306]

MR. MURRAY: Well, Mr. Chairman, I would sure like to say something. But decorum prevents me from pursuing it.

CHAIRMAN PAGLIN: You will have your opportunity, Mr. Murray. I am talking about the time. I see the hour is almost a quarter after 5, we have had a long day. I expect that Mr. Roisman will be here tomorrow morning because I have some questions I want to address to him. Then perhaps you will have an opportunity.

MR. ROISMAN: Yes, I will be here.

Do I understand that Mr. Kendall and Dr. Radford can be excused.

CHAIRMAN PAGLIN: Is that correct, the Board members have no further questions of Drs. Kendall and Radford?

(No response.)

CHAIRMAN PAGLIN: They may be excused.

We will resume at 9 a.m. tomorrow.

(Whereupon, at 5:10 p.m., the hearing was adjourned, to reconvene at 9 a.m., Friday, 2 February 1973.)

[307]

UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

IN THE MATTER OF:	Docket No. RM-50-3
URANIUM FUEL CYCLE	

New Executive Office Building
Room G2008
17th & H Streets
Washington, D.C.
Friday, 2 February 1973

The above-entitled matter came on for hearing pursuant to notice, at 10 a.m.

BEFORE:

M. D. PAGLIN, Esq., Chairman
DR. JOHN C. GEYER, Member.
DR. M. J. STEINDLER, Member.

APPEARANCES:

(As heretofore noted.)

[308]

PROCEEDINGS

CHAIRMAN PAGLIN: Good morning, ladies and gentlemen. We are resuming the nuclear fuel cycle hearing this morning. The dedication of the people who came here to this hearing in view of this rainfall is without measure.

This morning we would like to have some questioning by the Board members of Mr. Smiley first, and then we would like to put some questions to Mr. Roisman, and thereafter,

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according to our schedule for today, we will then proceed to the presentation by the Atomic Industrial Forum, and that will be followed by Mr. Freeman's presentation on behalf of Baltimore Gas & Electric, and the other utility companies appearing jointly, to be followed by the New York State Atomic Energy Council, and then Mr. Dzugan of the Minnesota Pollution Control Agency. Those are the schedule of appearances for today.

All right. Now, Dr. Steindler, do you have some questions of Mr. Smiley?

DR. STEINDLER: Yes, I do.

There was a comment made yesterday that a portion of the fuel cycle is outside of the area of licensing authority of the Commission, and I think you referred to compliance and the U.S. Bureau of Mines apparently is the group that has charge of that area. Can you comment on whether or not — or can you comment on the quality of the **[309]** standards used by the Bureau of Mines in their assessment of both worker safety as well as environmental impact? The quality of the standards as it relates to the kind of standards that you use in those areas in which the Commission has licensing authority.

MR. SMILEY: Well, I am not sure how to answer your question. We, of course, have very strict standards for people who work in the fuel cycle plants we have control over. And that is for every part of the fuel cycle. We do not have jurisdiction, as we indicated, over the workers in the mines. And I guess I am really not prepared to comment on the levels that they use for the workers in the mines.

DR. STEINDLER: All right —

MR. SMILEY: Also these are state functions, too, just as a lot of other operations which are under the Bureau of

Mines, for other types of mining operations are state functions. In other words, it is not an uncommon thing for the states to have this kind of responsibility.

DR. STEINDLER: Is it then reasonable to assume that portions of the fuel cycle being under the jurisdiction of various agencies, not only various departments within the federal government, but also the various states, could encounter a variety of standards both in terms of subject matter as well as quality?

MR. SMILEY: No, I would not go that far. The [310] mines, I think we would have to say there are standards, I believe, set up by the Department of Labor and the Bureau of Mines. I would like to make one other comment on the rest of the fuel cycle, which you addressed yourself to, and then ask Mr. Nussbaumer to comment on the other question you asked.

The only other operations that we do not control are the gaseous diffusion plant, where there are standards set up. And the mills that are in agreement states. Now we do have a program with the agreement states where by statute we make a finding that the agreement states have programs that are adequate to protect the public health and safety. And also compatible with our own. We make these findings every year. So I think it is too broad to say that we do not have some control over these activities. We work very closely with the states.

As I indicated yesterday, there is a group called the Radiation Program Control Directors, it is actually a national organization, or at least involves the program directors from all of the states, and they meet on specific problems involving radiological health, not only with respect to the fuel cycle, but other activities, such as x-rays, for ex-

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ample. And they are looking very closely at the points that you mentioned.

Just as a case in point, there was a meeting held—
[311]
excuse me just a minute, Dr. Steindler.

There was a meeting held back, I think, in February of 1972. This was a seventh session, they called it a federal-state enforcement conference. And a board of conferees, which included representatives from New Mexico, Utah, and Wyoming unanimously endorsed the adoption of model regulations which would require stabilization and long-term care of uranium mill tailings. Approximately 88 percent of all of the U_3O_8 reserves in this country are from those states. So to that extent, there is control quite comparable to our own.

Now there is the question you raise of the miners. Perhaps Mr. Nussbaumer would like to make a few comments on that.

MR. NUSSBAUMER: I think it is important to note in that regard that on the standards for uranium miner exposure that there has been input from not only other federal agencies, but many of the scientific experts in the country, and a couple of years ago the Joint Committee on Atomic Energy held hearings on the proposed standards of the Department of Labor, and received testimony from medical and health physics authorities on the adequacy of the kinds of standards that should be used for this purpose.

So the point here is that although the Department of Labor and Bureau of Mines have responsibility, they do
[312]
receive input from other agencies who have competence and from other individuals who have competence in this area.

DR. STEINDLER: Thank you.

I have another question. There has been some discussion, perhaps not totally adequate to provide a meaningful record for the Commission, on the whole question of global krypton-85 and tritium, the impact of the fuel cycle on the total amounts on citizens. Since there has been some comment that the document itself is perhaps not as explicit in this area as it might be, would it be possible for you to comment on both what has been said and the general attitude of the Staff?

MR. SMILEY: Yes. It has been stated that krypton and tritium do enter the earth's atmosphere and this is quite true and for this reason we are very conscious of the problem, and it is a question we address ourselves to specifically and in great detail in the review of fuel reprocessing plants.

I think it was stated yesterday that the tritium balance, for example, was such that there might be a difference of factors of two or three in how well people knew tritium. I think that is probably true.

I think what should have been said also, though, there was mention of hydrating or trititing of the zirconium and I think what should have been said is that any attempt at the balance, for example, at the NSF plants, has always [313]
come up with tritium values that are very low, like 20 to 30 percent of the actual value.

I think it is fair to say these are noncharacteristic fuels, as far as the LWR is concerned. They are special fuels. I am not trying to say only 20 or 30 percent of the tritium that most people say will arrive at the reprocessing plants or reach the atmosphere actually is the figure. It could be

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substantially higher than that. But technology does tell us in terms of tritium that chances are it will be lower than what you calculate, because of the hydrating effect of zirconium.

From what I recall of personal experience, I think the pressure and the temperature of operation of the reactors is such that you do favor this trititing effect. So I would expect not to see, I would expect to see less than we actually report.

In terms of our calculations, taking tritium first, we do assume that all of the tritium that is generated by calculation enters, or becomes an effluent. In the cases of the Barnwell plant and the Midwest Fuels Reprocessing Plant, that tritium will be put out the stack, at a controlled rate, pretty much at the rate that the stuff is produced.

In terms of NFS, it goes two places, part up the stack and part of it goes into Buttermilk Creek. That ratio is fairly well known, too, incidentally.
[314]

I think that question came up, and I think you actually answered the question yourself, as I recall.

Now the amount of tritium we are talking about in terms of whole body dose, which is the way the item of most concern is, is very small. And from our own calculations, we have concluded that at the Barnwell Plant, which incidentally will handle 50 annual reloads, 50 annual reloads, the whole body dose from tritium will be a little over 1 millirem annually. That is from the whole plant. That is for all 50.

And to put that in perspective, I recently had occasion to go to California and I believe it got something like eight or 10 times that on my trip to and from California by flying at about 30,000 or 35,000 feet. So that is the amount of,

that is the radiation level or the dose at the perimeter. This is at the site perimeter of Barnwell for tritium.

[315]

DR. STEINDLER: Is that because of the vapor expulsion of tritium through the stack?

MR. SMILEY: Yes, it is vapor expulsion and proper dispersion factors are used in the calculations. Now, tritium can be expected, as I explained yesterday, to enter the water strictly by condensation or other mechanisms of exchange.

So essentially, the tritium ends up reasonably close to the site, like in the 50-mile radius we use in the demography study.

So that is not the kind of thing you see in terms of getting spread all over the universe, as you would see with the krypton, which I will comment on in a moment.

So the amount of tritium is small.

I would like to make this point. I would also like to make the point, since it was brought up, that it has been small at NFS, as have all other effluents from NSF relative to standards. They have never exceeded the standards that were set. We can comment on that if you care to go into the question.

The krypton is another question. Here again, however, calculations will show that at a plant the size of Barnwell, the amount of radiation from krypton is extremely small. Again, we are taking care of 50,000 megawatts electricity a year at this one plant, the discharge of fuel of [316] that amount.

One of the reasons it is small for the whole body is the fact that krypton is mainly a beta emitter, so it is mainly skin dose that you get. It makes a very small contribution

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to the whole body. It contributes about one-fifth of the total exposure of whole body. So when I said a little over millirem, that was tritium and krypton at the site.

As to the skin dose, our calculations show — I think I heard a number of 200 millirem to the skin at the MFRP, Midwest Fuels Reprocessing Plant. That is not the number we come up with. We came up with a number at MFRP of 4 millirem to the skin, about 13 at Barnwell.

Of course, our calculations, we would be pleased for anyone to review these calculations. We have not only looked at the data that has been presented to us, but made independent calculations of this. I think these numbers check pretty closely with the other numbers I have seen, like the study of the year 2000.

So we are talking about roughly 4 millirem at MFRP, and about 13 millirem to the skin at a plant like Barnwell, that handles 1500 tons of fuel a year.

In terms of whole body dose, there are some interesting observations. First of all, by the year 2000, a lot of people talk about the year 2000, only 30 percent of [317] the total amount of krypton produced will come from the United States. The rest will come from the rest of the world, but you can still make calculations, assuming that all of the krypton stayed in the Northern Hemisphere, which is a conservative calculation, the conclusion we reach is that by the year 2000, there is less than — let's see — there is less than 500ths, .05 millirem, dose that will come from krypton to an individual, less than .05 millirem per year annually.

This compares with a number which, in this country, is about 140 millirem as natural background, if you have a guy living in a house, a little radiation in the brick, a little in the diet, this kind of thing, .05 millirem per year.

Now, this is not to say that we are trying to make a judgment at this point that all krypton for this reason should be allowed to enter the atmosphere. We have not taken that position. But we do feel because of the fact that in the year 2000 such a small amount to individuals will be the dose, we certainly don't have a problem today. I think everyone will readily agree.

I heard yesterday comments made about the fact that one of the problems may be with ALAP on reactors is maybe the values were so low now that the Commission had gone too far and you couldn't measure the stuff.

[318]

I would like to point out we are talking about doses even lower than the ones described in ALAP on reactors. So, on that basis, we have reached the conclusion that we do not have a problem at this point.

But in talking about krypton to the world's atmosphere, we have not closed the options on processes to remove krypton. It is well known that the Commission has programs to remove krypton, and we are following these very closely.

But unlike what we read every once in a while, it is stated that the problems are solved, and that we could put these in effect right now and it is strictly an economic factor, that is just not true, and I can make comments to this effect, because, as a regulatory agency, we are looking truly at the health and safety picture, not just at maybe what might seem the right thing to do at this point?

There are several problems with krypton stripping that have not yet been solved. First, chemically, there are a lot of — unlike at the reactor site, once you dissolve the fuel, there are a lot of impurities in the off-gas from the reprocessing plant, so that just to say that you can trap krypton and xenon with TNA fluorocarbon and remove it, does not say you have a safe system.

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You have to prove that all of these trace impurities that are in the off-gas will not affect the [319] performance of your system and further, not create a hazard. You can get explosions, for example, if you trap oxidizing materials in the freon system of it, as I am sure Dr. Steindler is well aware.

Now there are programs being carried out, there is a program at Oak Ridge Gaseous Diffusion Plants, where a lot of this work was startedon krypton-xenon, to trap them, and, in fact, to study these impurities.

This is from our standpoint an excellent technical program and we are watching it very closely. Then, the question comes up, once you have trapped it, you must also strip the krypton out of the freon in a concentrated form and store it. Well, if you store it at pressure, now you have the question of whether or not you have created a problem by storing at high pressure. If you ship this out to some site, you have to have a container which will meet all of the standards on shipping casks.

I could say more about it, but fundamentally, the krypton problem we don't see at this point: tritium whole-body dose is extremely low. We have kept our options open. We have required that those plants building reprocessing plants have the capability of installing krypton treatment systems.

One company went out for a system and got five R&D proposals, so it is not like the technology is easily available. It is different from reactors, because of [320] the off-gas problem.

Would you want me to comment on iodine at all?

DR. STEINDLER: Well, I think the problem is iodine is a lot more chemically related. I can appreciate that

there is chemistry in iodine and there is not chemistry in krypton. I don't have a question on iodine and I don't see that the issue has been raised significantly here.

MR. SMILEY: Okay.

Does that handle what you asked?

DR. STEINDLER: That is fine.

I have one other, though.

The report is relatively silent on the topic that was brought up yesterday by Dr. Kendall, and that is the question of diversion.

It comes under the heading of safeguards. I wonder if it is not worthwhile to clarify this record for completeness to indicate what licensing procedures are followed in very broad terms that touch on the question of security?

MR. SMILEY: Well, of course, we in the Commission consider the subject of safeguards very, very important. And I might add here is another area where we work closely with the rest of the Atomic Energy Commission in terms of policy, to be sure we are getting our best information and to take advantage of research and development activities.

We recognize that you can have severe consequences **[321]** if you have problems in safeguards, and so we do have some rather strict rules as far as the operating plants are concerned with regard to safeguards.

And I would also like to mention at this point, and then say a little more about it, that on Tuesday, a press release was made, the title is "AEC Announces New Restrictions on Special Nuclear Materials," and it says:

"The Atomic Energy Commission today announced a series of broad restrictions to its regulations governing

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the protection of special nuclear materiasl by Commission licensees."

I want to say a word about that. I think I ought to say, first, that the reason that we were rather sileng on it in this report is, as you and others commented yesterday, when you talk about the light water reactor, UO-2 fuel cycle, you don't have strategic materials, except the plutonium that is stored, and even that stuff, without really commenting further, it is certainly a strategic material, it does have 24 percent plutonium 240 in it, that burns up at about 25,000 megawatt days per ton.

But we have broad policies that we have established on safeguards and we have some very specific regulations, including technical specifications for our contractors.

For example, when we review a license application, we look at three things. We look at the safety, and we **[322]** certainly addressed that question in the environmental survey; we look at the environment, and that is addressed mostly in the survey; and we also look at special nuclear materials control.

Now, the AEC requires each licensee application for possession of special nuclear material exceeding 5000 grams of contained U-235, uranium 233, or plutonium, or any combination of those materials that are in what we call unsealed form to provide a detailed description of their material control and accounting systems, and these systems consider procedures used in receiving, storage, and shipping special nuclear material, procedures for controlling special material during processing, physical inventories, and then an organization in the facility, an operating organization that properly takes care of these functions.

Furthermore, the licensee must provide, by our requirements, AEC requirements, protection systems which consider control of access to radioactive material and components being protected, detection of unauthorized access, or an attempt to gain unauthorized access to radioactive material and components, communication between personnel on-site, who are responsible for protection, and those people with a local law enforcement agency which can provide meaningful assistance in a threat situation, and a response by a combination of those personnel on-site who are responsible **[323]** for protection supported by personnel from a local enforcement authority, as may be required.

Now, we have had requirements like this for some time. They are very specific for the Midwest Fuels Reprocessing Plant, which stores plutonium.

There is a buddy system; there are TV cameras; fencing; perimeter lighting, all of these things.

So, essentially, our system is defense in depth. We look at the accountability system; we look at physical protection in the plant; and we look at methods of doing something about it were anybody to try to break in and enter.

Now, I think there is a 2-page — if you will allow me, there is a 2-page summary of the new regulations which are written in about a space and a half, if I could read now, and submit the rest ofr the record, people might be interested in this.

Would this be satisfactory? These cover protection of special nuclear materials in transit also.

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CHAIRMAN PAGLIN: Yes, I think it would be relevant for the participants in the proceeding to have it before

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them, since it may become material in commenting in the written submissions.

MR. SMILEY: Very good. I have one more comment after that on it.

It says, "AEC Announces New Restrictions on Special Nuclear Materials.

"The Atomic Energy Commission today announced a a series of broad revisions to its regulations governing the protection of special nuclear materials by Commission licensees. The plan has been under development for more than a year.

"One amendment, effective immediately, sets forth restrictions on the transportation of plutonium and enriched uranium by domestic passenger aircraft as an added safeguard against theft or diversion.

"Other changes which are proposed and will become effective later involve the safeguarding of truck transportation of the materials and would establish tighter rules on inventory and physical protection.

"The new regulation prohibits licensee shipments aboard passenger aircraft of more than 20 grams or 20 curies," — for plutonium coming out of reactors, it turns out the burn-up is perhaps one, the relationship is about 1 curie per gram. It is much higher than on 239 and lower on 238 [325]
because of other built-ins — "whichever is less, if plutonium or uranium-233 and shipments of more than 350 grams of uranium-235 enriched to more than 20 percent.

"The limitation on plutonium and uranium-233 are consistent with international air transport regulations governing shipments of these materials aboard passenger aircraft. They also are consistent with export license conditions

which have been imposed by the Director of Regulation since February, 1969, limiting shipments of special nuclear materials on international flights.

"AEC Chairman James R. Schlesinger said that the Commission's action, which is effective immediately, is part of an amendment to its regulations which has been under development for more than a year. In announcing the rule change, he said:

" 'While there have been no thefts or diversions involving shipments of special nuclear materials, the number of shipments will increase significantly in the years ahead and it is imperative that all possible precautions be taken to safeguard them.'

"In the past, the only significant quantities of nuclear materials handled by AEC licensees have involved low enriched uranium, used in light water power reactor fuels; the shipment of this low enriched material is not affected by the new amendment. To date, relatively small quantities of [326] plutonium have been shipped by AEC licensees, primarily for use in research and for small scale industrial applications such as oil well logging and neutron activation analysis.

"However, over the next several years, licensees will be handling significant quantities of plutonium to be used in the breeder reactor program and, in combination with uranium, as recycle fuel for the current generation of power reactors; in addition, as more high temperature gas-cooled reactors are placed in operation, licensees are expected to handle greater quantities of highly enriched uranium.

"In addition to the limitations on passenger aircraft shipments, the Commission also is proposing additional restric-

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tions on motor transport of nuclear materials as part of a series of amendments to its regulations which would substantially strengthen precautions to prevent diversion of nuclear materials handling by AEC licensees. Under the proposed amendment governing shipments of special nuclear materials, licensees using trucks or trailers to ship important quantities of these materials would be required to provide an armed escort traveling in a separate vehicle or to use a truck or trailer especially designed to protect against theft or diversion.

"In addition to providing new protection for shipments of special nuclear materials, the proposed amendments would: (1) apply stricter physical inventory requirements
[327]
to more special nuclear materials and increase the frequency and quality of required inventories; and (2) require a licensed nuclear facility to provide additional measures specifically for protection against industrial sabotage and establish areas with special physical barriers to protect special nuclear materials used, stored, or possessed.

"The Commission's action on passenger aircraft shipments is being made effective immediately because of the increased number of highjackings during the past year which have led to tightened airport security.

"A more detailed description of the effect of the proposed amendments which will be pubished in the Federal Register on February 1, 1973, is attached. Interested persons are invited to submit written comments."

I can put this in.

CHAIRMAN PAGLIN: Excuse me. What is the date of that release?

MR. SMILEY: Tuesday, January 30.

DR. STEINDLER: What is the number?

MR. SMILEY: R-36. I have copies of the actual proposed regulations if the Board would like to see them, which we can give you.

Now I would like to say this, that I think the summary hit on a point I was going to make very well. There really has been very little strategic material involved up [328] until now. And we have handled the work on a case-by-case basis. It is very true, and this is outside of this hearing, but organizations like NUMEC and Kerr-McGee, who are doing fuel fabrication and are handling hundreds of kilograms of plutonium for the fast breeder program, have strict regulations, protection, inventory control, and this method of contact with the local law enforcement agencies.

But we see now the growth of the industry and these new regulations are meant to show that we recognize this problem and have recognized it for some time, and now with the growing plutonium economy, perhaps, and certainly with the U-235, and HTGR, we must be aware of it, and our proposed regulations have been offered.

We plan to do more on this. Regulations are alive, you know, and we will watch them constantly, as we will in the safety and environmental areas.

I made a comment about MFRP having regulations in force. They are not running yet, at least not to produce plutonium, they are in cold shakedown. But these are the license conditions and they will be enforced.

DR. STEINDLER: I have no further questions.

CHAIRMAN PAGLIN: Dr. Geyer?

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DR. GEYER: In connection with physical protection in storage, what kinds of facilities are provided? AEC doesn't have a Fort Knox installation, does it?
[329]

MR. SMILEY: No, sir. The facilities are similar to — they are right in the reprocessing plants in one case, and at a special site in New York State in another. But what we are talking about in terms of physical protection, accountability systems, et cetera, will be used. If something is in storage, there are undoubtedly special license conditions which will assure that material is what is in there. We don't have a special plant, except for the fact that at MFRP the whole thing is behind five feet of concrete, and there are special vaults where the plutonium is stored.

DR. GEYER: Were other than vault doors such as used in the banks, for example?

MR. SMILEY: I would defer to Gerry Page on that. He is the head of the safeguards branch in our organization.

MR. PAGE: The license conditions that we have been incorporating in the Kerr-McGee and NUMEC license, Exxon, Jersey Nuclear and others, require that material in storage must be protected by intrusion alarms with a specified response time. We do not specify foot foot thick walls in all cases, but we do require that this material be stored in a protected area, it be within an outer fenced area, and that it be protected by intrusion alarms tied in with a manned central guard station.

As Mr. Smiley mentioned, there must be a communication network between the plants and local police.
[330]

DR. GEYER: Do you have actual vault doors that would be very difficult to breach?

MR. PAGE: There must be doors there, and these must be of substantial construction. We do not say how thick they must be. This is something that we judge on an individual application basis.

DR. GEYER: Thank you.

MR. PAGE: In many instances they will be vault thick doors.

MR. SMILEY: I was asking him what the weight of the container was. I want to point out in shipment that this is an interesting concept, that these containers are fairly heavy, so it is not like you are walking off with something you can pick up and carry away.

DR. GEYER: What do you mean by fairly heavy?

MR. PAGE: I think perhaps what you are referring to, at the storage facility, as in New York, nearby to the West Valley Plant, the material is stored in very large containers and you need special handling equipment in order to remove the containers.

DR. GEYER: It is not in a size that they could carry out and put in the trunk of a car?

MR. PAGE: On the order of a ton.

MR. SMILEY: It is bigger than a bread box.

DR. GEYER: Thank you.

[331]

CHAIRMAN PAGLIN: Are there any other questions by the members of the Board from other members of the Regulatory Staff?

(No response.)

CHAIRMAN PAGLIN: If not, may we proceed and again the inevitability of time begins to push me.

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MR. MURRAY: Mr. Chairman, I would like to note the Staff will be available, should questions arise later on today.
[332]

CHAIRMAN PAGLIN: Yes, that is our understanding, thank you.

We would like to proceed to some, I won't call it questioning exactly, but discussion with Mr. Roisman at this stage. The members of the Board have some questions of him. Again I will try to proceed as expeditiously as possible in order to accommodate all of the participants in today's hearing.

Mr. Roisman, I think it would not serve any particular purpose for us, myself and yourself as lawyers, to engage in a legal debate at this particular hearing. However, I would like to raise some points with you, those made in the course of your remarks yesterday, and more in terms of having both yourself and the other participants, when they submit their written submissions at the conclusion of the oral hearing, to address themselves to these matters as legal propositions.

You indicated, and quite rightly, that these are critical matters, procedural matters, but nevertheless critical matters. There are some legal questions involved, not necessarily as I see them as a matter of authority of the Commission, but perhaps more so in terms of the visibility, the desirability, and the necessity of the procedure involved.

I have particular reference to the fact that you referred yesterday, Mr. Roisman, to — I think you put it the public demand a generic hearing with full rights of [333] discovery and cross-examination.

May I observe by way of footnote, I take it you mean the public in terems of your role or the role of your organizations as private attorneys generally, not necessarily the vast mass of the public, because I take it you would agree with me none of us come with a diploma of divine guidance signed by the Lord God Jehovah. None has that, we are all mere mortals looking for guidance in this matter.

But what I would like to have you address briefly now and perhaps more extensively in your paper is, first, I take it you would recognize legally there is a distinction with respect to the authority of the agency to hold a legislative type hearing under the Administrative Procedure Act as against an adjudicatory hearing.

Would you also concede that the cases hold — again this is not a legal debate, I'm just making the point and I would like the others to address themselves to it in their perhaps memorandum of law which will be filed — that the courts, including the Supreme Court, have held that due process does not necessarily require full evidentiary hearings, full cross-examination, full discovery in every instance.

In other words, the Supreme Court has said in the Morgan case what due process is, what it requires. What I'm getting at, Mr. Roisman, is I would like for you to treat the [334] matters of what you define as "a generic hearing with full rights of cross-examination and discovery" as against the authority of the agency to have a policy-formulation proceeding in the mode of something other than a full-scale evidentiary hearing where it is not required by the statute.

Have I gone on too long in that "question"?

MR. ROISMAN: No. I will of course address it in written comments, but to begin with of course there is no dis-

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pute with the proposition that an agency does have the authority to conduct a legislative type proceeding such as this one, which includes no rebuttal, no cross-examination, no discovery, and is like hearings before Congressional committees. The issue of course if whether or not this hearing can serve as the hearing with regard to the substantive documents, the survey of the environmental effects of the nuclear fuel cycle.

There is no doubt that it is an appropriate hearing for the Commission to make up its mind which procedure to put into effect. And that is why we made no objection to the conduct of this hearing in exactly the form it is in.

We are here to urge the Commission to hold a substantive type hearing, adjudicatory in nature, as the rule that it ought to adopt. But there is the implication and we think the implication is subject to some debate in the Commission's Alternative Number II — as you understand, we reject **[335]** Alternative Number I on the purely legal grounds that we don't think it meets NEPA — but there is an implication in Alternative II that the documents we have been discussing may, following this hearing, become a complete statement of the environmental effects of the fuel cycle, and not the subject in an individual licensing proceeding, when that data is read into the impact statement, to cross-examination or discovery.

Now the phrase in question is at the very end of Alternative Number 2, as it appears in the Federal Register, in the third column, page 24,192. It states in part —

CHAIRMAN PAGLIN: It has so many phrases, why don't you just start ". . . shall be as set forth."

MR. ROISMAN: That's right.

"The environmental costs of licensing the nuclear power reactor shall be as set forth in the following Table S-3 of the Commission's Environmental Survey."

Now if the term "shall be as set forth" means shall be and not subject to any questioning, that would seem to me to eliminate the right of an adjudicatory hearing on the substance of what appears in Table S-3. That we would say would not be within the Commission's discretion, since they would have instead of taking a matter which is subject to rule-making, appropriate for rule-making, would have taken a substantive matter that would appear in an impact subject **[336]** and assumed it to a non-adjudicatory hearing, namely this discussion, and fed that back into the impact statement and insulated it from discovery, cross-examination, and rebuttal and the like.

It is equally subject to the interpretation that all the Commission is saying is when the Staff prepares its impact statement it will take Table S-3 and put it in and as you know, everything the Staff puts in the impact statement is then open to contention in an individual licensing proceeding and you would be able to come in and say, "Staff, we have seen your fellow documents, but we are still not persuaded, we want to see this and this underlying document," and eventually the appropriate contentions are made, conduct cross-examination of the Staff on that.

If that second interpretation is the right one, we feel it would produce an incredible burden on the Commission and one it shouldn't have to take on, because you then would have the problem of repeating many of the same questions and issues and contentions in every hearing; you are talking about the same general group of reprocessing plants, the same group of uranium mills, et cetera.

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For that reason we urge and we note that many people in the industry support the concept of the generic type hearing, that it be done in the generic form. But even if it were in the discretion of the Commission to choose to do this [337] particular matter in the legislative type hearing route, we also make the point that we think that that is not a wise choice for the Commission to make if it is attempting to exercise its discretion.

There is, as I pointed out before, and I don't think this is a fact which can be disputed, a distrust in the country, at least in segments of the country, of the Commission and its statements and the industry and their statements regarding the safety and the reliability of nuclear power plants.

To the extent that the Commission forecloses full public discussion, forecloses the opportunities to cross-examine and discovery with regard to the issues, it tends to exacerbate those public doubts. To the extent that it opens them up to fuller explanation, real problems that do exist come to the fore, and false ones, which appear to be there, but weren't in fact there, are laid to rest.

And so we believe that even if the Commission did have the authority to take this fuel cycle report, subject it only to a legislative type hearing and then bind the participants in an individual licensing proceeding to its contents, that wouldn't be a smart course of action or one that would best serve the public interest.

Now of course I would be happy in our legal submittal to discuss the question of why I think the Commission does not have the discretion, and why I think that this document, [338] as opposed to the rule-making on which

procedures to follow, this document must at some stage in the procedure be subjected to the full adjudicatory rights under the Administrative Procedure Act.

CHAIRMAN PAGLIN: In other words, what you are in effect I think saying is that the Kenneth Davis concept — Forgive us, please, two lawyers talking about these things — the legislative fact against the adjudicative fact.

You are saying there should be an opportunity to challenge the accuracy of the data upon which the Commission would want to act. On this I have no quarrel. Again I would like the participants to address the matter as a legal subject in perhaps a memorandum of law to the Commission, because as I see it, as I mentioned during the procedure planning session in January, to me, — forgive me for repeating it — the name of the game in rule-making is not only to permit interested and affected parties to comment on the proposed rule, but also to assist the agency in reaching as fully informed and as valid as possible a decision.

I frankly, Mr. Roisman, do not see this in terms of antagonists or adversaries. I would say parenthetically for 28 years I worked for another Government agency in the regulatory field which was always referred to as the "big bad FCC." It was with some chagrin I heard you yesterday and it made me think I'm now working for the big bad AEC. I don't **[339]** think that is a fact.

Again not to be facetious on such a serious subject, we are all in this together and we are trying to find the most valid route. I think that acrimony and condemnation — again I'm making personal comments — do not exactly help an agency in reaching an informed decision.

The points I think you agree with me on are to show

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the road to the Commission that if in fact it needs further proceedings of a particular nature in order to realize the validity of the facts on which it wishes to act, this is the route it should go as a legal matter. I don't think we disagree on this.

But I think it would be helpful to lay it out as a legal matter by all of the parties for the Commission, so it can arrive at an informed decision.

MR. ROISMAN: Mr. Chairman, if I may, just one comment. I think that first of all the question of is the AEC a bad bunch of people, that implies again some statement about motive and we have not gotten, nor are we attempting to get into the question of motive. I don't have any doubt that the people —

CHAIRMAN PAGLIN: I would hope not.

MR. ROISMAN: — the people in the Commission do what they do out of conviction.

Let's say our position is they are misguided in [340] some respects, but not that they are in any respect immoral.

CHAIRMAN PAGLIN. Mr. Roisman, so long as you recognize that the ultimate doom, that big cloud, would envelop not only the members of the Commission, the Staff, but all of us, so we are all involved.

MR. ROISMAN: Absolutely.

But I think also your experience in the Federal Communications Commission— I'm sure you are aware it took the then Judge Burger, now Chief Justice, to say not once but twice in the Office of Communications of the United Church of Christ that an intervenor was not to be treated as an interloper, but was to be treated as someone who has something to contribute.

CHAIRMAN PAGLIN: Absolutely.

MR. ROISMAN: I don't know that one may say the Calvert Cliffs decision was the Commission's Office of the Church of Christ, it may be the Commission still needs one.

In any event, I think it merely proves that even well-intentioned agencies can, over a period of time, begin to drift away from serving the public interest and it is not unlikely that someone has to give them a slap on the wrist. That has been the courts in the past and it may have to be courts again in the future.

CHAIRMAN PAGLIN: You will admit however you now have had your forum to make this statement, in terms of on the **[341]** record.

MR. ROISMAN: Oh, yes.

[342]

CHAIRMAN PAGLIN: Let me address one more question, Mr. Roisman, and this is likewise to the other participants, again.

I gathered, from your remarks at the opening before the testimony of Doctors Kendall and Radford, that your group, at least, was saying that — perhaps, I am oversimplifying it — that there should be a cessation of all activity in terms of developments of nuclear energy until certain safety features could be assured.

What I would like for you to address yourself to, in your paper, is whether or not you think this proceeding, Number One, and Number Two, the Commission testimony, is the proper forum for the determination of a matter of national policy of that kind, or are you speaking of addressing the Congress when you, in effect, assert that there

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should be, as I read it, a cessation of the developments of nuclear energy as an energy source.

I say I don't think, at this stage, perhaps, you will will agree with me, Mr. Roisman, that it requires response by you. I make my point, and I would like to see it developed, because I think, again, it is a critical point in terms of the appropriateness of the forum.

MR. ROISMAN: If I may, Mr. Chairman, since you do raise the question of Congress, and since many of our participating organizations are tax-exempt organizations, I don't [343] want to leave any misimpression on the record. It is our opinion that the Commission's responsibilities, under the Atomic Energy Act, as written, gives it the authority, if it feels that sufficient safety does not exist in the industry, to simply stop licensing plants.

It would either do it on a generic basis, if it were a generic problem, or a case by case basis. It is not necessarily a legislative solution. But, I will address that in detail, and cite references, and so forth.

CHAIRMAN PAGLIN: Thank you, Mr. Roisman.

Dr. Steindler, I think, has some questions at this point.

DR. STEINDLER: Perhaps they are not so much questions, but, perhaps, an attempt to provide for the Commission, some clarification in the transcript. Is it reasonable to assume that the points made by your group, Mr. Roisman, include for example, the following; and I am sure you appreciate I am trying to address myself to the more technical aspects, rather than procedural: The fuel cycle — is it reasonable to assume we can attribute to your group, the opinion, that the fuel cycle documents, as written, and as presented, here, is (1) Too narrow in scope

and should include the reactor as well; and (2) Is too narrow in scope, and should include in detail, such things as ultimate waste disposal?

Let me stop there, and ask you to respond to that?
[344]

MR. ROISMAN: Yes.

DR. STEINDLER: That is a fair statement, okay?

Now, if this fuel cycle document should include the reactor, as well, I presume that you would try and treat the reactor as a generic beast, as we treat the fuel cycle bits as generic beasts.

Is it your contention that that is a feasible way to proceed, recognizing that ultimately, the reactors are different by virtue of their location, their type, et cetera?

MR. ROISMAN: Yes. I think — I said this yesterday — certainly, there are site-related characteristics, and also differences; boiling water, pressurized water, size, and even within pressurized water, not only two manufacturers, but different designs from the same manufacturers; which are not suitable to a generic hearing.

But, on the other hand, we have already participated in two hearings which do relate to reactor questions,, namely, emergency core cooling system, and as low as practicable. And we feel that there are other subject areas which are equally generic in nature.

I am not nearly in a position, primarily because of technical limitations to give you other examples, of places where, I think, that this can be done. But, we know that there are common elements in reactors, similar pumps, you may have seen if you are on the most-favored, mailing lists

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of the [345] Commission that in the last six or eight months, a number of letters have been sent to reactor operations, or people with construction permits, that dealt with the identical problem, and it was the same letter sent to each one of the utilities: teh steam line running problem, the problem associated with fuel densification.

These are problems which at least suggest that there are generic type resolutions of these problems, and we are, despite some intemperate comments, to the contrary, in no way interested in having these decisions take very long, because we feel that if those decision prove that nuclear power is not a good solution: we want the country to turn its substantial resources toward the alternative sources of power before it is too late.

DR. STEINDLER: Let me, from here, split into two other questions.

I think it was pointed out, yesterday, and I don't think there is any tremendous disagreement, that the ultimate perpetual storage problem is one that is not soluble at this point in time, because it is not definable.

You indicated, because of your philosophical background, you have some problems with that particular concept. I also then would like to turn this around, and wonder whether or not your group would view the problem of not having terminal disposal capability clearly identified at this point — I might [346] add, I also have a philosophy background, and I have the same kind of problem in saying that today we are able to do something for all time.

But, if we don't have the terminal disposal of one of the aspects: namely, the fission product wastes, completely solved at this point, does that represent to your group, a

sufficient reason to stop everything until we can accomplish what I think may well be not difficult and impossible?

It is a question I tried to address to, I think, Dr. Kendall, and I am not sure I got an answer to that.

MR. ROISMAN: Let me see if I understand it. If the premise is it will probably be impossible to find adequate permanent storage of wastes, given what we all know about the potential damage of wastes, I must say I would be surprised if any members of our group; although I have not polled them on the question, so I won't try to speak for all 81 member organizations, but I would be surprised if any of them would vote to go ahead with nuclear power.

If the premise is, we don't now have a solution, but we have a very strong indication that we will have a solution ten years from now when we need it, would you stop; again, I can't speak for every member of the group, but I can certainly speak for the — can certainly speak for the Board of Directors of Consolidated National Intervenors, and for the members of the Union of Concerned Scientists, who have participated in [347] this proceeding, Dr. Kendall and Radfor, that under those circumstances, there certainly needs to be a severe re-evaluation of the question of proceeding with the developments of nuclear power.

Again, given the initial premise, what we know about the dangers associated with nuclear wastes, can we, in good conscience, proceed with it. And, that does involve, to some extent — and this is where you get not only into the Atomic Energy Commission Act, but into the National Environmental Policy Act, also — a really basic kind of cost-benefit analysis, again, under the premise that we adopt now, have a solution to the long-term storage of nuclear waste, permanent storage.

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But, we have indications we will have it sometime in the foreseeable future. And, if we have alternative sources of electric power in the country, and alternative ways of supplying our demand by reducing demands or increasing supply or both, then you are faced with a much different set of options than if the situation is one in which you could say, conclusively if you didn't have nuclear power; you could not, say, run iron lungs in hospitals.

Our own position is that the latter is not the case, that there are enormous options still open to the country in terms of electric energy, that as we continue down the nuclear route, many of those options get foreclosed, simply
[348]
because when its current gets 10 or 15, or 20 percent of its electric power from nuclear plants, instead of the one or two percent, it has, now, it is more difficult to turn that off, and find an immediate replacement for it.

DR. STEINDLER: I think the thing that concerns me is we get into a position where we don't cross the street, because we don't understand, fully, how the stop-and-go light works, if you will pardon that analogy.

The problem I am trying to address myself to is to get from you, a definition of how you view the problem of waste handling? Is it in the judgment of your group, mandatory that the "ultimate disposal problem," in fact, be attacked at this point in time?

MR. ROISMAN: There is no doubt about that. I mean we start from the premise that if this were a red-and-green light situation, it would be a much different situation. We are talking in terms of the nuclear waste problem, with dangers to the entire world, and the world population.

Given that those are dangers which, but for nuclear power plants, would not ocme into existence, that is, you

are talking about not naturally occuring waste products, we think one must face that question and must have something concrete in the way of a solution available.

At this time, all we can do is examine what has been the past history of attempts to solve the problem and they have [349] not been particularly good. Lyons, Kansas turned out not to be what it was cracked up to be, and that did not instill much confidence in us.

DR. STEINDLER: I am trying to draw a distinction between the disposal of waste in an irretrievable, out of sight, out of mind approach, versus the disposal wastes in a retrievable and desirable fashion, where, in fact, you pay attention to it.

Both of those obviously represent viable long-term solutions if you are willing to pay attention to them. I don't want to get into the philosophy of Weinberg's Legacy, which is another topic, altogether. All I am trying to distinguish is whether or not your group considers the disposal problem in which you, in fact, drop your wastes into a situation where you pay attention to them, does this represent, to you, an adequate long-term, not infinite, but long-term solution to the disposal of wastes?

MR. ROISMAN: I think at that point, you have crossed beyond my expertise. I can give you some of the considerations, but I don't feel competent to give you an answer.

DR. STEINDLER: Fine. Let me suggest that that issue has come up sufficiently so that, perhaps, a short comment consequently in your written material would be worthwhiel. I think this is the fundamental issue. I may have it not quite clarified, but I think that is one of the fundamental issues.

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[350]

MR. ROISMAN: What bothered me the way you framed it was it is difficult for me to comprehend the question without including Weinberg's priesthood. I always thought what Weinberg was calling for was an international organization to which everybody in the world would belong; all of our ancestors would be keepers of the nuclear waste mound, of which we all are charter members.

I do think you cannot answer the question if you say the solution is long-term surveillance, without saying historically, how long have we been able to keep our eye on things, King Tut's tomb, and some of the other pyramids are just one of the examples of things in which one society attempted to set something aside and say, "This is inviolate, nobody is to get into it," put curses on it, and so forth, and consequent societies did not believe that.

I think we feel fairly confident, at this point, and I don't have any doubts about the technical theories that those wastes would be extremely hazardous and lethal if they got released. We don't want some future generation, for whatever its reasons, to decide, "Gee, we have been working in the these mounds for 250 years, let us leave them alone. Nothing can happen here." And, then, of course, something would happen. And, I just don't think you can separate the philosophical question from the reality question.

But, I understand your question, let me see if I [351] restate it correctly, if there is a long-term surveillance solution to the waste disposal problem, would our organizations oppose that and say, "No, no surveillance to the waste problem is every going to be a viable alternative," and the only solution must be a nonsurveillance solution.

Does that state what you are asking, basically?

DR. STEINDLER: In effect, that is what I am asking. And particularly, don't extend the tempered into infinity for the answer, even, you know, Christianity, as long as it has lasted, has had some alternatives provided for it by others, no matter what you think of them.

So, we do set up things, we do set up religions, and I didn't want to get into Weinberg's priesthood, but we do provide alternatives on occasion which some of us feel are just as viable as the others.

[352]

MR. ROISMAN: We will try to keep it within a thousand years or so.

DR. STEINDLER: Fine. I have one other question as a matter of procedure. A great deal of the discussion could have centered in this particular hearing around the technical detail of this document.

Unfortunately, we avoided that, otherwise, I think we would be here for a prolonged period. However, you indicated repeatedly and emphatically that cross-examination and what is termed the right of discovery, which I don't understand, but I don't need a clarification on it now —

CHAIRMAN PAGLIN: I will tell you about it later.

DR. STEINDLER: Right. — is a process which you feel to be the best way to arrive at the truth, I think. Coming from a scientific domain, I understand cross-examination to be a strange way of arriving at the truth. I think there are probably more efficient ways which are divorced from the personality cult which cross-examination could possibly be interfered with.

Is it not possible, as far as you are concerned, that those aspects which represent technical matters, not judgment

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matters, but technical matters, could not be resolved in a way in which you say a referee referees a journal article in the scientific field or on a more impersonal and technically related mechanism? Would you not [353] think that would be perhaps more appropriate, or at least an equally useful way of settling a large bulk of the problems that perhaps pertain to the technical deficiencies you might see in this document?

MR. ROISMAN: Let's see. I guess I can start with the legal comment that ours is a nation of laws, not of men. The principle is if you go through the proper procedure, you have a higher probability of finding the truth. But there is no doubt on certain technical problems, maybe on many of them, that an alternative forum is the kind of forum in which two technical people, or five, or whatever the number is, sit down with someone there who is competent and unbiased and who simply says, "Wait a second, you are missing an issue, talk about that as well, to work something out." I think we have discovered in the emergency core cooling system hearings that to some extent that is true in this respect. When the hearings began the Commission had a panel of experts that they put up as their panel to testify and they were subjected to cross-examination. As the hearing proceeded, it was uncovered that there were other experts not sitting up on the panel, but also Commission personnel, who worked either at the National Laboratories or within the Commission, who had differing views, and there at least began to develop a feeling that perhaps what we saw at the cross-examination stage at the beginning in terms of the Commission's panel [354] were people who were reviewing other people's work and putting their own interpretations on it, and that what we found ultimately were the people who had actually been involved in the work,

further removed from policy considerations, and further removed from the secondary interpretations of what somebody is doing.

If you can have a discussion at which all of the "principals" are involved, and in which there are no limits — as you know, the Commission is a schizophrenic organization and it has this dual responsibility to promote and develop nuclear power. If you could take that away, my own experience has suggested that as you move further from the center of gravity, literally geographically speaking, further from Washington, there is a greater tendency for the policy and the promotional side of the Commission to influence what happens and therefore discussions with people from National Laboratories who work with the same subjects that people within the Commission worked on tended to be franker. That is a prerequisite, the frankness of the conversation.

In addition, we have got to remove the inate bias that people have. One of the purposes of cross-examination is to expose the bias, so that when a man says on the witness stand the consequences are small, or that the figures fit well, what does he mean when he uses the word "small" and what does he mean by a good fit.

[355]

Ultimately, all language, going back to the philosophy, unless we think that Bertran Russell really came up with the perfect language, which I don't, has to have qualitative terms in it. One purpose of cross-examination is to expose what assumptions underly the qualitative terms. You spoke yesterday about the question of what assumptions underly this document. Cross-examination would be one way to get at that. I don't think that cross-examination need either be a conflict of personalities, nor a situation of acrimony. I have seen it both ways, with similar participants involved.

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It can be a useful exercise in which both people are trying to explain their positions and the questioner simply helps them.

Obviously the technical questioner is more appropriate for the technical witness and we have favored that whenever we have technical expertise. You understand our groups have been limited by much smaller technical expertise, so, to wind up a long answer to your question, I am not opposed to the principle of something other than cross-examination to get at these and I would be perfectly willing to try it as an alternative, but being a lawyer, without waving my right to cross-examination.

But if the Commission wanted to take the fuel cycle question and say it looks to us like this is one particularly suitable to this kind of thing, and we are [356] prepared to call in all of the people who have something to say on this subject and start the discussions, I think we would be willing to start that, and if that came up with what we thought was a thorough examination of it, we wouldn't go through the incantation of discovery and cross-examination merely for the sake of it. It is a tool to achieve something, not an end in itself.

DR. STEINDLER: Fine. I think the only reason I bring it up is because I have been involved in processes where it is not cross-examination, but just the kind of thing you are talking about, where five guys sit around the table and, in fact, hash out very seriously a technical problem and arrive at a consensus, where these five represent at least two sides, if not three, they have done it successfully. We have done it within the Commission and without the Commission. So I think there is some advantage, if that represents a meaningful way, as far as you are concerned, of posing that as a potential solution to some problems, put-

ting it in the record and letting the Commission mull over the approach here that they might choose to adopt.

MR. ROISMAN: I will ask our technical people if they have any comments on this to include those. Your mention of five people sitting down with three views, you see, if it were five lawyers, they would have seven views, and that may be the difference between our disciplines.

[357]

DR. STEINDLER: Yes. That is all I have.

CHAIRMAN PAGLIN: Dr. Geyer?

Again by way of footnote, this is an example of what I was referring to, Mr. Roisman and the others, please do not hesitate to use ingenuity in terms of suggestions for procedures to assist the Commission in this very complex task.

If Mr. Wiggin would permit me, I would like to call for a moment on Mr. Murray. Mr. Murray, there is no Section 315 of the Communications Act here, or any requirements for eaual time as such, but I do feel elemental fairness requires you be permitted some comment at this stage.

MR. ROISMAN: Excuse me, do I understand you are allowing staff rebuttal, and, if so, when may we have rebuttal?

CHAIRMAN PAGLIN: No, it is just a question.

MR. ROISMAN: I hope there are no questions by any participants. I understand that has been ruled on.

CHAIRMAN PAGLIN: No, it is a question.

MR. MURRAY: I understand you were asking me a question and I was prepared to respond.

CHAIRMAN PAGLIN: Would you go ahead. This is not rebuttal, no, sir. I have some comments at the end before we close the hearing about this.

MR. ROISMAN: What is the question Mr. Murray is
[358]
responding to?

MR. MURRAY: The same one you were asked, I assume.

CHAIRMAN PAGLIN: Yes, about procedures.

MR. ROISMAN: Thank you.

MR. MURRAY: Mr. Chairman, we feel that these hearings are being held to obtain the views of anyone and everyone on the light water fuel cycle, which doesn't involve any shipments of plutonium or highly enriched uranium. We also feel that these hearings are being held to obtain even eroneous views of anybody. However, when we get views that go far beyond the proper scope of this hearing and they are eroneous, we don't quite know what utility to make of it. We have heard nothing whatsoever contravening any of the factual information in the survey. That is what this hearing is for. We haven't heard — we have heard a lot of philosophy about what we ought to be doing, but we haven't heard anything attacking the factual basis.

In the absence of any factual contraventions, Mr. Chairman, there is no reason for a judicatory proceeding. That process is for getting at facts, not for dealing with philosophical questions, as was shown in 122 days of hearings in ECCS. We have heard the ECCS hearing retried here and mischaracterized, the same with the as low as practicable hearing. But we haven't heard any factual contravention of the documents.
[395]

CHAIRMAN PAGLIN: Well, I would expect, Mr. Murray, that that is what I was referring to when I said in the written submissions, if you can raise the questions with respect to the factual validity, this would be assistance

to the Commission. It would then point the way as to what further procedures may be necessary.

MR. MURRAY: Mr. Chairman, Mr. Smiley has a point he wants to add.

MR. SMILEY: The question of small and these other descriptive words has come up, and I would like to clarify that. The words are used through the text. But I would like to make it very clear, there is a summary table in the front, Table S-3, which appears in the *Federal Register* notice. It doesn't appear in its entirety in the *Federal Register* notice, only the radiological considerations had additional comments, if you recall, the nonradiological did not. We may have used words like "small" and "insignificant" in the text, but in Table S-3, we took every factor, and we characterized it in some form, so someone would understand what that means.

For example, under the radiological, under "Gas, including entrainment," it will say "tritium," for example, principally from fuel reprocessing plants, whole body dose 4.4 man rem for population within 50-mile radius. This is less than 0.005 percent of average national background dose — **[396]**

CHAIRMAN PAGLIN: Excuse me, Mr. Smiley, I don't think it is quite important to make this point at this stage. I think this point can be made in your responding papers. You are responding to Mr. Roisman's characterization, I understand that. But I don't know whether it is relevant at this point.

MR. SMILEY: Fine, we will make it in writing.

CHAIRMAN PAGLIN: Please do.

I want to ask Mr. Wiggin what is his preference? He is now scheduled to proceed. They have 90 minutes. Would

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you prefer to start now and take a breat at 11:00 or prefer to take a break now?

MR. WIGGIN: Take the break now.

CHAIRMAN PAGLIN: Fine. 10-minutes.

(Recess.)

[397]

CHAIRMAN PAGLIN: May we resume?

We will now hear from Mr. Wiggin on behalf of the Atomic Industrial Forum.

Mr. Wiggin.

STATEMENT OF EDWIN A. WIGGIN, EXECUTIVE VICE PRESIDENT, ATOMIC INDUSTRIAL FORUM

MR. WIGGIN: Thank you, Mr. Chairman.

I am Edwin A. Wiggin, Executive Vice President of the Atomic Industrial Forum and also I am Secretary of the Forum's Committee on Nuclear Fuel Cycle Services. It is in that capacity that I am appearing here this morning.

This statement is based in part on the input of the Steering Group of the Nuclear Fuel Cycle Services Committee. Our statement also includes the input of the Forum's Mining and Milling Committee. Mr. George L. Gleason, Vice President, Program Director and Staff Counsel of the Forum, is with me and will address the procedural aspects of our statement, when I finish the technical portion.

The Forum is a not-for-profit membership association incorporated in the State of New York. Its members comprise some 550 corporate and institutional members in the United States as well as in some 25 other countries, all of which share a common interest in the development and application of atomic energy for peaceful purposes.

Because of the diversity of its members, which [398] include utilities, manufacturing companies, universities, labor unions, professional firms, financial institutions, government organizations, and other profit and non-profit entities, the Forum, as a matter of policy, does not take independent positions on matters pending before the Congress or pending before other public interest and quasi-judicial bodies such as this Board; however, whenever possible we do make an effort to identify relevant technical, legal and policy considerations and to provide a mechanism for determining and articulating the views of our various members.

The question before this Board is whether the environmental effects associated with the uranium fuel cycle should be considered in individual light water power reactor licensing cases. In its implementation of the National Environmental Policy Act, the Atomic Energy Commission has concluded that environmental statements for a power reactor should not only weigh its potentially adverse environmental impacts against its environmental, technical and economic benefits but also quantify to the fullest extent practicable and incorporate in the environmental statement a cost-benefit analysis of related factors.

It will be the responsibility of this Board to assemble the evidence that will permit the Commission to determine whether a related factor to be so considered is the uranium fuel cycle. A further question facing this Board and the [399]
Commission is the manner in which this should be done.

An Endorsement of Approach.

We endorse the Commission's generic approach to resolving these issues, as we did its approach through rulemaking hearings to the problems of setting low as practicable limits on radioactive effluent releases and establishing

ECCS criteria. Indeed, in keeping with a long-standing recommendation of our Lawyers Committee, we believe that the Commission should seek additional instances in which its regulatory requirements can be established by general rule rather than on a case-by-case basis.

The Commission's Regulatory Staff has prepared an "Environmental Survey of the Nuclear Fuel Cycle" to serve as a basis for determining if and in what manner the environmental effects of the uranium fuel cycle should be included in the environmental statements of power reactor license applications. Further, the Commission has proposed in amendments which it is considering making to Appendix D of 10 CFR Part 50 and which are described later in this statement alternative ways in which this might be done.

Scope of the AEC Staff Survey.

Since the Staff survey provides the bases for both of the alternatives set forth in the Commission's proposed amendment to Appendix D, it would appear appropriate to address the survey before considering the merits of the two
[400]
alternatives.

In its survey, the AEC Staff has considered the following elements of the fuel cycle: mining of uranium ore; milling and refining of the ore by uranium concentrates; production of uranium hexafluoride feed; enrichment of the gaseous diffusion process; fabrication of reactor fuel; reprocessing of the irradiated fuel; management of radioactive wastes; and transportation of various fuel forms from one phase of the cycle to another.

We will want to speak to each of these steps. We will also want to comment on several elements of the nuclear

fuel cycle which the Commission, following the lead of its Atomic Safety and Licensing Appeal Board, has determined should not be included in this general rulemaking hearing, but instead considered in the individual environmental statements of reactor license applicants, including transportation of nuclear fuel from the manufacturer to teh reactor; the shipment of irradiated fuel from the reactor to a fuel reprocessing plant; and the transportation of high- and low-level solid wastes from the reactor to federal depositories.

Finally, we will want to comment on three additional aspects of the nuclear fuel cycle which the Commission has indicated it will consider at a later date, presumably when they become more significant factors in license reviews; specifically, plutonium recycle in the present generation of [401]
light water reactors and the fuel cycles for gas-cooled and fast breeder reactors.

A Commentary on AEC's Model Approach.

In attempting to come to grips with the magnitude of the task involved in assessing the over-all environmental impact of the nuclear fuel cycle as it pertains to the licensing of reacto-s, the AEC Staff has chosen a "model" approach. Such an approach, however, is not without certain shortcomings. For example, the "model LWR" is neither a pressurized water reactor nor a boiling water reactor, but combines certain characteristics of each in such a manner as to postulate a maximum environmental impact from the fuel cycle facilities supplying materials and services.

Similarly, the AEC survey employs model fuel cycle facilities which in some instances combine alternative processes and operations used in as many as three different

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plants, all designed to serve the same purpose. As the AEC Staff has pointed out, "where the nature of the impact from two or more modes of operation differs significantly, the aggregate operation of all plants, normalized to an appropriate annual capacity, has been selected as the model fuel cycle facility . . . The models were selected to be representative of the industry and to lead to conservative or pessimistic assessments of the environmental considerations."

Adoption of the model approach, it seems to us, [402] imposes three obligations on the Commission. First, it must be established that the models selected in each of the fuel cycle steps do, indeed, lead to conservative or pessimistic assessments of the resultant environmental impacts.

Second, the AEC has stated that "the model fuel cycle facilities are not intended to represent particular plants." It should be clearly established in the record of this proceeding that the data characterizing the natural resource use, the gaseous, liquid and solid effluent releases, the radioactive materials release, and the thermal discharges, on either an individual or industry-wide basis, will not necessarily serve as applicable or appropriate guides in the licensing of specific fuel cycle facilities. The report indicates this to be the case and the Staff has so testified.

Third, it should be made clear that to the extent the model approach leads to what may appear to be inconsistencies between parameter numbers characterizing the model and parameter numbers characterizing a specific fuel cycle facility, such inconsistencies have arisen simply from an effort to be conservative and do not compromise the value of the conclusions reached.

Uranium Mining.

In its survey, the AEC staff has chosen as its model uranium mine an open pit mine in contrast to an underground mine on two premises: (1) that about half of the [403]
known uranium reserves in the U. S. are located in relatively shallow — less than 400-foot deep — sedimentary formations and (2) that the environmental effect is greater in terms of the total volume of earth disturbed.

In comment, we would observe that the future fuel requirements of nuclear power reactors will depend — and this was indicated yesterday — to an increasing extent on uranium reserves that have not as yet been confirmed, i.e., on uranium ores that presumably will be found as the result of current and future exploration efforts. The trend of recent exploration findings is that a significantly greater proportion of uranium reserves now being proven lie well below the 400-foot level and hence must be recovered by underground mining operations.

As the AEC survey, itself, points out "a greater fraction of the ore mined in 1980 may come from underground mines." Hence, to the extent that underground operations impact less severely on the environment, the relative impact of future mining operations should be less than those postulated in the AEC survey.

Although we would acknowledge that the area of land described in the AEC survey as permanently committed is some 50 times greater in an open pit operation — 2.0 acres versus 0.05 acre to meet the annual fuel requirements of the 1,000 Mwe LWR model — we question whether any land is permanently [404] committed when land reclamation practices, as now required by many states, are followed. Further the trend of state and federal legislation appears to be to require complete reclamation of all lands affected by any type of mining operation.

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Commenting further on the AEC survey's model open pit uranium mine, the Forum's Mining and Milling Committee has noted that the 1,500 gallon per minute water drainage is a higher rate of discharge than has been experienced in open pit mines currently in operation. Also, depending on the relative location of the mill serving the mine, the discharge water may not be released to the natural surface drainage system, but instead used as mill process water. In this case, it is ultimately impounded with the mill tailings.

Even though precise data may not be available, the Committee has suggested that the AEC survey summary on effluent releases should perhaps include an estimate of the radioactive materials released to the atmosphere as a result of open pit mining operations. The Committee points out that the principal radioactive nuclide released in radon-222 and while the rate of its release will depend on the surface area of ore exposed, it is conceivable that the amount released could be equal to that released from a comparable quantity of mill tailings.

However, the concentration of radon-222, as well as the concentrations of other airborne radionuclides in unrestricted areas, i.e., 600 meters or more from the point of
[405]
release, would be expected to be undetectable.

The AEC survey points out that approximately 250 megawatt hours of electric power are consumed in an open pit mining operation, primarily for the operation of dewatering pumps, to meet the annual fuel requirements of the 1,000 Mwe LWR model. On the assumption that the electrical generating capacity is coal-fired, the AEC survey cites a level of resultant SO_x, No_x, hydrocarbons, and CO effluent releases.

The Forum Committee points out that in an underground uranium mine of comparable size, power consumption would

be higher by a factor of 20 or more because of the heavier power demand of ventilation equipment. In such cases, the chemical effluent releases would increase by a comparable amount.

Although the AEC survey does not address the problem because it cannot be considered an environmental problem impacting on the general public, publication of the survey has raised again the question of the hazards to underground radiation miners from exposure to decay daughters of radon gas. As of July 1, 1971, the permissible radiation exposure for mine workers was dropped from a standard of 12 working level months — WLM — to four WLM per years. A WLM is 170 hours' exposure, or its equivalent, to one WL of activity which in turn is defined as 300 picocuries, one-billionth of a curie or 660 atomic disintegrations per second — per liter of air.
[406]

Through a combination of ventilation equipment, electrostatic precipitators, and respirators used in conjunction with brattices and stoppings and the maintenance of negative pressure air flow behind stoppings, it has been possible for most uranium mines to meet the new standards. It is significant that available data shows that in terms of the amount of electric power generated versus the number of employee fatalities from all causes, it is safer by a factor of four to 20 to work in an uranium mine than to work in a coal mine.

Uranium Milling.

The Forum Committee on Mining and Milling has concluded that the AEC survey adequately covers the uranium milling step of the fuel cycle. It concurs in the selection of the acid leach process for the model plant because of its predominant use over the carbonate leach process and

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agrees that the acid leach process will impact more significantly on the environment.

As the survey points out, a carbonate leach mill uses less than a third of the water that an acid leach plant uses and hence the amount of water discharged to the air in the carbonate leach mill is much less. Also, a carbonate plant recycles the leach solution whereas the model acid leach plant does not.

And finally, the carbonate leach mill recycles tailing pond solution back to the mill for pulping the filter plant [407] solids and as a result tailing pond liquid inventory is lower.

In only one respect does operation of an acid leach mill result in a smaller environmental impact than a comparably sized carbonate leach plant. The carbonate plant has an approximately 40 percent higher thermal discharge output since the leaching process must be carried out at elevated temperatures, whereas the acid leach process is carried out at ambient temperatures. The additional incremental environmental impact is not considered significant.

On only two other features of the survey's model mill did the Committee have comments and in both instances the consequences are so small as to disregard them. The Committee pointed out that the model mill was located adjacent to a mine property. In instances where this is not the case, the temporary commitment of land to access roads, parking lots, and service buildings could be larger.

Also, in a specific mill study conducted for purposes of comparing its results with those of the AEC su-vey model, it was found that the amount of radiological liquid effluents in the form of uranium and daughters is approximately three times larger. However, since the numbers being compared are two versus six curies for the annual fuel require-

ment of the model LWR, neither is believed to have any significant impact on the environment.

The hearing's consideration of uranium milling and [408] disposition of the tailings it produces may provide an occasion for recalling the unfortunate incident which led between 1954 and mid-1966 to the use of uranium mill tailings as fill under and around an estimated 2,000 homes and other structures in the Grand Junction area. While no immediate or long-range health hazard has been proven — even those areas of fill shown to have "excessive" radon levels are appreciably below permissible mine radiation levels — extensive adverse publicity during the last two years is understood to have led to economic penalties to owners of the affected homes and at least temporary damage to the image of Grand Junction as a tourist and light industrial area.

Last October, the AEC and the State of Colorado signed a contract agreement which will permit up to $5 million in Federal funds authorized by the Congress and up to $1.25 million in state funds authorized by the Colorado Legislature to be spent on appropriate remedial steps — either removal of the tailings or the use of liquid styrene plastic sealant to block out the emanating radon gas.

The AEC survey addresses the problem, or at least the unlikelihood of a recurrence, in noting that where the Commission has control over licensing it will require mill operators in the future to provide assurance that funds will be available for reclamation of a tailings storage area when mill activities are terminated. The Commission will further require [409] the operator for a period of 50 years not to permit:

(1) exposure or release of the tailings material to the surrounding area;

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(2) building structures on the covered surface which man or animals can occupy;

(3) subdividing the covered surface; or

(4) establishing private roads, trails, or rights-of-way across the covered surface.

Uranium Hexafluoride Production.

The AEC survey treatment of uranium hexafluoride production presents the first instance where the model plant selected, a 50:50 composite of two totally different processes, may lead to some difficulty in interpreting environmental impacts. As the survey, itself, points out:

"The nature of the effluents from the two processes differs substantially; the hydrofluor method produces effluents primarily in the gaseous and solid state, and the wet solvent extraction method releases mostly liquid effluent."

It follows that the environmental effect of a plant built with either process could be significantly different than the average of the two processes.

Since the survey includes extensive descriptive material on both processes and since the AEC assumes in selecting the composite model that "roughly equal quantities of [410] UF_6 feed to the enrichment plants are produced by each method," one might weight the summary data in such a manner as to approximate the performance and hence the environmental impact of either type of plant.

Beyond this observation, we have two comments on the summary treatment of UF_6 production in the overview section of the survey, neither of which would be expected to grossly affect the values indicated.

There is a question as to whether a specific value should be shown for a specific thorium radionuclide, Th-230. It is our understanding that the thorium content, as well as the mix of thorium radionuclides differ markedly, depending on the source and age of the uranium concentrates received. The UF_6 producer can, of course, exercise no control over this; his task is simply to remove them udring the course of his operations in order to meet the chemical specifications of the UF_6 product.

We assume that the thermal effluent value in the summary was calculated from the quantity of natural gas consumed. In this connection, it might be noted that all electric energy consumed by a conversion plant will appear as thermal effluent discharge except for minor energy level differences between feed materials and the UF_6 product.

Uranium Enrichment.

Since all three existing uranium enrichment plants [411] are owned by the Commission and since only limited information has been put into the public domain on their classified operations, it would be difficult, if not inappropriate, to attempt to comment in detail on the AEC survey's treatment of this step in the fuel cycle.

Three brief observations may, however, be in order.

First, it would undoubtedly prove helpful to those companies now considering an involvement in uranium enrichment to have access to the environmental report or statement on which the numbers in the AEC survey report are based.

Second, if, as has been suggested, new enrichment facilities were to rely for their power needs on nuclear power stations, in contrast to coal-fired stations, the impact on the

environment from the release of gaseous effluents could be expected to be less than those shown in the survey.

Third, it might prove helpful to potential owner-operators of new enrichment facilities to have available to them a more extensive treatment of accident considerations than is contained in the current survey report.

Fuel Fabrication.

A poll of companies currently engaged in nuclear fuel fabrication indicates general concurrence with the AEC survey treatment of this step in the nuclear fuel cycle. This is not surprising since the nuclear industry, with the exception of the uranium mining and milling segment, has had a longer record [412] of involvement in fuel fabrication than in any other phase of the nuclear fuel cycle. For this reason, the amount of information available to the Commission on commercial fuel fabrication operations is extensive and this is reflected in the data presented and the conclusions drawn in the survey report.

On only one point did the fabricators offer a substantive comment. They thought it important to point out that the summary values on effluent releases in the overview section of the survey report are those derived from a material banace analysis of the model plant's operations and hence should not be considered as characteristic of any particular plant other than in an average reference sense. Although this point was made by the AEC staff in describing its model plant approach, several other industry representatives in other segments of the fuel cycle have made the same point with respect to summary data on their particular step of the fuel cycle and hence it would appear to bear repeating.

Reprocessing Irradiated Fuel.

The model reprocessing plant, like the UF_6 production plant model, may lead to some difficulties in assessing environmental impacts resulting from the reprocessing of irradiated reactor fuel. In this instance, the problem is more complex in that the model is a composite of three plants, rather than two.

Further complicating matters somewhat, one of the [413] three plants is still under construction, another is approaching operations, and the third has temporarily suspended operations for modification and expansion of its capacity. The three plants do, however, share some common features in that they all rely on mechanical means for removing the irradiated fuel from the cladding and all of them use adaptations of the Purex process for at least some portion of the separations carried out.

In reviewing the characteristics of the model plants normalized to the annual fuel requirements of the model 1,000 Mwe LWR, as described in the summary of environmental considerations, a number of comments have evolved which may call for some modifications although none are of such a magnitude as to change significantly the over-all environmental impact.

For example, a value of ten to describe the ratio concentrations of I-131 to I-129 in radiological effluents is more typical of fuel that has cooled or decayed for 180 days rather than the 150 days stated to be the basis of the calculations. Also contained in these numbers is the implication that the reprocessing facility should be able to recover in excess of 99.9 percent of the radioiodine contained in the fuel.

Laboratory experiments carried out under ideally controlled conditions have indicated that it should be possible

[414]
to achieve such recovery. However, there is no evidence that this degree of recovery has been demonstrated in a reprocessing plant where hundreds of pieces of equipment are involved and circuitous routes for discharge of volatile materials can and do develop.

We believe, under the circumstances, that it would be more realistic to assume that the concentrations of the two nuclides in the radiological effluent release can be held to the equivalent of one-thousandth of the permissible concentration limits in air specified in 10 CFR Part 20, the Commission's regulation on protection against exposure to radiation.

An additional comment on the radiological effluents reported is suggested by the unlikelihood that a liquid waste stream released as liquid or as steam vapor would contain only tritium and ruthenium-106. To represent the other radionuclides present it is suggested that 25 curies of gross fission products and two curies of transuranics should be added to the reported liquid effluents.

Still another comment is that it is unlikely that a reprocessing plant would generate steam from coal as postulated. The more likely fuel would be oil which suggests that the levels of NO_x effluent discharge should be increased somewhat and the levels of SO_x effluent discharge decreased.

A final comment relates to the waste management [415] section of the survey report, but is entered here because it deals with the operation of a reprocessing facility. The survey report states that the spent fuel from a model LWR processed annually in a fuel reprocessing plant produces approximately 1,000 gallons of radioactive liquid waste. Presumably, this amount of waste is equated to a 35 metric ton

batch of irradiated fuel which means that the 1,000 gallons of liquid waste would be equivalent on a unit basis to less than 30 gallons/MTU.

Because of solids buildup from the precipitation of fission products and the potential for localized corrosion if heat generating solids remain in contact with the walls of the liquid storage tank, dilutions called for would probably necessitate maintaining a ratio of 100 gallons/MTU and more likely 150 to 300 gallons/MTU. This means that the volume of high level liquid wastes to be handled would be five to ten times greater than has been indicated.

Radioactive Waste Management.

The AEC survey's treatment of radioactive waste management appears to be an adequate discussion of the manner in which low-level wastes are now handled and the amnner in which high-level wastes are to be handled in the future. The discussion, we believe, also portrays an accurate assessment of the minimal potential impact on the environment that these operations anticipate.

[416]

In view, however, of the adverse publicity and controversy that this subject has provoked during the past year, we find it unfortunate that the survey's treatment is not less apolegetic and not more positive in tone. We do not question that some of the concerns expressed in the past have been sincere and perhaps even justified to the extent that straightforward and convincing answers could not be, or were not, always available in response to pertinent questions raised.

We believe, however, that those concerns were predominantly, if not exclusively, directed at AEC's proposed approaches to ultimate disposal of high-level wastes, not to the long-term management of those wastes.

[417]

I make a very definite distinction between the two techniques, and that was discussed this morning.

There is nothing in AEC's extensive experience in handling some 90 million gallons of high-level liquid wastes or in industry's more limited experience in handling some 600 thousand gallons of high-level liquid wastes that suggests there has been or is likely to be, any adverse impact on the environment. Nor is there any reason to believe that AEC's plan to store such wastes in the future in solid form in cooled and shielded near-surface engineered storage facilities for up to 100 years does not provide a more practical solution.

The AEC has indicated that all necessary technology is available for constructing the facilities; for removing the heat generated by the wastes; for monitoring and surveillance of the facility, the coolant and waste canisters; and for maintaining or repairing failed or deteriorating facilities, equipment and canisters.

As the AEC has further pointed out, what needs to be done now is to select a site, to choose the particular engineering approach which offers the most practical and efficient solution to specific design and engineering problems and to construct the facility.

If the industry has any criticism of the AEC approach, it is not with the validity of the concept or with [418] AEC's ability to develop and carry it out, but rather with its apparent lack of appreciation of the need for early determinations that will bear on long-lead time actions of the industry.

As early as mid-1969, the AEC informed the industry of its intent to require all high-level wastes generated in reactor fuel reprocessing operations to be converted within

a five-year period to an AEC-approved solid form and to be transferred within a 10-year period to a federal repository, the location of which would be designated at a later time.

As of this date, almost four years later, the Commission has still not indicated what form of solid waste it will accept, where the federal repository is to be located, or what charge will be assessed to defray the costs of storage and surveillance.

Even though the AEC does not intend to seek Congressional authorization for initial funding of the engineered facility prior to the FY 1975 budget submission and does not expect to receive the initial shipments of such solid wastes until the early 1980s, it needs at an early date to come up with answers to the questions suggested above so that the industry can handle its responsibilities under the plan in an orderly fashion.

Transportation.

Conclusions drawn from the transportation section [419] of the AEC survey report appear to be valid and, indeed, consistent with other sections of the report in that estimates of environmental impact are conservative, i.e., larger than experience suggests they are likely to be.

On the other hand, we are not sure that the treatment is sufficiently definitive to lead some readers of the report, particularly those not familiar with the physical, chemical and radiological properties of the various materials transported between successive stations of the nuclear fuel cycle nor with the manner in which these materials are packaged and shipped to understand or appreciate the bases for the conclusions reached.

It is for this reason that we believe the value of the report would be enhanced if the survey treatment were amplified. We would include:

(1) A brief description, with accompanying illustrations, of the various types of containers used to transport various materials. Included in such descriptions should be sufficient reference to the contents to permit the reader to understand the nature of the hazards and consequences in terms of environmental impact if an incident or accident were to occur in the handling or transport of the container. For example, in the shipment of fuel materials up to the enrichment stage any problems encountered would arise not from the radiological properties of the materials, but rather
[420]
from their chemical properties. This type of shipment is not unlike the shipment of most bulk solid chemicals.

(2) Additional information on why the consequences of an accident would be expected to be negligible, including, for example,(a) that packages are required to be designed to withstand severe accident conditions with no loss of confinement or other essential package function, (b) that the probability of a package being involved in an accident of the degree of severity assumed in setting design requirements is far less than the probability of the package being involved in an accident, and (c) that the testing program on which shipping container specifications are based involve such conditions as a 30-foot freefall onto a flat unyielding surface, a fire in which the package is subjected to a temperature of 1475 degrees F for 30 minutes, and complete immersion in water.

(3) Expansion of the summary table in the overview section of the report to indicate the normal radiological effects of the various transportation steps shown. Such

an expansion, we believe, would provide a basis for comparing the resultant levels of potential radiation exposure with those in other steps in the fuel cycle and thereby demonstrate the very low environmental impact associated with the transportation segment of the nuclear fuel cycle.

Other Issues.

[421]

We believe, as is pointed out below, that attention should be given to the following issues which have been intentionally omitted from the survey:

Plutonium Recycle.

Reference has been made to this in the testimony yesterday.

The AEC survey report points out that plutonium recycle in the present generation of LWR power reactors will be considered in future documents. Subsequently, the report refers to the fact that the feasibility of using plutonium in a mixed plutonium-uranium oxide fuel for LWRs has been demonstrated, that the timing and extent of its future use is an economic matter to be considered by each utility, and that between now and 1975 or 1977 limited means for storing the recovered plutonium product inventory will be provided at the three nuclear fuel reprocessing plants.

Although we concur with this assessment of the situation, we wish to make three observations, each of which suggests that steps should be immediately taken by both the industry and the AEC on the technical and licensing fronts to assure routine plutonium recycle at the earliest possible date.

At the present time, there is in existence only enough storage capacity to accommodate some 2500 kilograms of plutonium, either as the nitrate or oxide. Although [422]

reprocessing plant operators will undoubtedly install additional storage facilities, the high capital costs of these facilities and the difficulties involved in the storage of plutonium, particularly in the nitrate form, both provide incentives for keeping the amount of stored plutonium to a minimum.

The direct relationship between the availability of plutonium for recycle and the requirement for additional uranium enrichment capacity provides a further incentive to recycle plutonium in light water reactors. Between now and the end of 1981, by which date the cumulative demand for enrichment services is expected to have equalled cumulative supplies, including pre-produced inventory, it will be necessary to have recycled 100 per cent of the plutonium that will have been generated; otherwise, our enrichment capabilities will have been exceeded by some 15-20 percent.

Finally, the argument can be advanced that the best way of minimizing the health and safety problems, the accountability and safeguards problems, and the shipping problems associated with plutonium is to assure its recycle in the minimum turnaround time possible.

Reference was made yesterday to the AEC plans to develop data for inclusion or generic treatment of the HTGR fuel cycle. We endorse the AEC's approach to the problem. As I say, sufficient data should be available soon, if it is
[423]
not already available, to permit consideration of the uranium-thorium fuel cycle used in the high temperature gas-cooled reactor. We believe the proposed rule change and supporting survey report could be couched in sufficiently general terms so as to include this fuel cycle without compromising the environmental assessments already developed. If this proved not to be the case, we would recom-

mend that the AEC Staff initiate at an early date the preparation of an appropriate addendum to the survey report.

The LMFBR Fuel Cycle.

The fuel cycle to be employed in the liquid metal fast breeder reactor is, we agree, too far removed in time from commercial reality to incorporate an assessment of its environmental impact in the present survey. Nonetheless, we believe that a mechanism should be established for amending the survey analysis when sufficient data becomes available to warrant such action.

Transportation To and From the Reactor.

Also excluded from the survey report is the transportation of fuel materials to and from the reactor, that is, the transportation of cold fuel to the reactor and irradiated fuel from the reactor to a fuel reprocessing plant and the transportation of low-level wastes and high-level solid wastes from the reactor to depositories. These transportation operations are excluded since the proposed rule **[424]** amendment would require them to be covered in the Applicant's environmental report and the Commission's detailed statement relating to individual licensing proceedings.

We do not see why these steps in the fuel cycle cannot be treated in generic fashion as is proposed for the other steps. There are no characteristics of cold fuel that we know of that warrant special transportation considerations. The shipment of irradiated fuel from a reactor to a reprocessing plant would appear to involve basically the same considerations as the transportation of high-level solid wastes from a reprocessing plant to a federal repository. And finally, the transportation considerations involved in the shipment of low- and high-level wastes would appear to be the same, irrespective of their origin or destination.

Since the survey shows that the effect of the fuel cycle on the licensing of power reactors is sufficiently minimal to suggest that it may need not be considered and since the survey shows the environmental impact of transportation to be comparatively less than in some other steps of the fuel cycle, we fail to see the justification for not treating all phases of transportation in a generic manner.

It is now our understanding AEC has prepared reports similar to the ones we are discussing here, and it is my understanding they do plan rulemaking hearings on this.

To sum up, we think it is a creditable, [425] important and useful compilation whose conclusions are essentially valid. It should prove of assistance to this Board and to the Commission in the further consideration of whether and in what manner the environmental effects of the uranium fuel cycle should be considered in individual light water power reactor licensing cases.

We also believe the creditability of those would be enhanced by placing some upper and lower limits on the operating results of some of those facilities.

Its usefulness would be enhanced if it were modified and amplified to include other steps in the light water reactor fuel cycle and the fuel cycles employed in other types of reactors.

If that is to be treated in a separate document in a timely fashion, that would certainly be a workable and appropriate mechanism.

Third, we feel the report should be limited to the purpose for which it is designed, that is, for assessing the environmental impact of the nuclear fuel cycle in the licensing of power reactors. It is not and should not be considered an

applicable or appropriate guide for the licensing of specific fuel cycle facilities.

In light of these comments and those submitted by others, we believe there is merit to considering the current edition of the survey report as a draft. At such time as [426] the draft is modified to include necessary additional information, perhaps further technical editing should permit the elimination of extraneous detail in areas of minimal significance and the inclusion of additional detail in areas of greater significance.

I would ask Mr. Gleason to take up the subject of alternative rules at this time.

MR. GLEASON: Would the Board desire to question on the technical aspects of our statement before I proceed?

CHAIRMAN PAGLIN: Let me consult.
[427]

CHAIRMAN PAGLIN: The Board would prefer the entire presentation be finished, and then go back to the technical questions, if there are any, Mr. Gleason.

MR. GLEASON: Thank you, Mr. Chairman. As the Board knows, the Commission has two alternative rules before it which we are issued in the Federal Registry, Notice for consideration, as to how the fuel cycle might be taken into account in the individual reactor-licensing proceedings.

Alternative One has been clarified by the Staff as the Board is aware of, and I won't go into the background of that. My understanding of Alternative One, as clarified, is that it is a codification of the Appeal Board's ruling in the Vermont Yankee Case, at least, in practical result, if not necessarily, in legal theory.

Alternative Two, on the other hand, provides for some consideration of the generic aspects of the fuel sycle in the individual reactor-licensing proceeding. This would be done on the basis of Table S-3, from the Survey, which is the summary section, and which Mr. Smiley has pointed out, does contain quantification of the environmental impacts.

The National Environmental Policy Act, its council on environmental quality guidelines, and the AEC rules in Appendis D to Part 50, all make it clear that cost-benefit analysis in the individual proceedings should contain a full, and frank disciosure of the costs and benefits of the proposed [428] action.

The reason we are here, today, is because there is some question, as was noted in the Commission's notice, as to how this principle should be applied in actual practice. It is not entirely clear.

And, in fact, as the Board knows from reviewing the filings that have already been made, there is a substantial difference of opinion among those who have looked at the rules as to which is the preferrable approach.

The split is not only among the lawyers, but is reflected, I think, as well in some of the technical comments that have been submitted. So, we think that the Board does have a difficult task in sorting out what is relevant with respect to each of the rules, and which is to be preferred by the Commission.

One group which is represented here by Mr. Upton has argued in favor of Alternative One, noting that the Survey indicates the insignificance of the fuel cycle impact with respect to an individual reactor. They also cite that in RDC Report for the proposition that the impacts, here, are remote and speculative, and not readily ascertainable.

As further reasons why the impact should not be considered in the cost-benefit analysis in individual proceed-proceedings.

Another group represented by Mr. Freeman, who you [429]
will hear from this morning, is in favor of a modification of Alternative Two, and their rationale is essentially that Calvert Cliffs, Appendix D, and so on, does require some consideration of these things, that we have a survey which has, to some extent, quantified those impact, and it is consistent with Appendix D, and with NEPA to consider this, generally along the lines which would be accomplished in Alternative Two.

The Atomic Industrial Forum has a Lawyers Committee within that Committee on regulatory procedures, and we have given some attention to both of these alternatives, and to some of the other alternatives, as well, which have been mentioned, and we were unable to reach a consensus in favor of one or the other.

For that reason, we are not, today, in a position to state a preference with respect to Alternative One, or Alternative Two, and I might add that anything we say here, with respect to those alternatives, because our lawyer's group has not taken a position, would necessarily represent my own individual views with respect to the alternatives.

We think our inability to reach a consensus does indicate the burden this Board has, and which the Commission has, in developing the kind of rationale that would be necessary to support either of the alternatives.

Indeed, it is not entirely clear and we think, the [430]
primary purpose of this hearing should be to provide an adequate record for the Commission to make those determi-

nations. While not taking a position, we would like to address to the attention of the Board, a couple of fundamental issues, we think ought to be considered.

First, of course, and this has been raised by Mr. Roisman, and others, is the Congressional question of whether each of the alternatives at least met the minimum requirements of NEPA, and the guidelines in Appendix D.

Second, and I think, this is a particularly important one, that I have not heard a great deal said about in this proceeding, so far, is the practical effect that each of the alternatives will have in the individual reactor-licensing proceedings.

In other words, if the Commission were to adopt Alternative Two, as a practical matter, what would the parties in the individual proceedings be required to do? And the same, with respect to Alternative One.

The final question is the impact which adoption of any rule, whether Alternative One or Two, or some other rule, would have on the cases currently in the licensing-process. The Commission notes in its notice, the continuing validity of the various proceedings.

Yesterday, the Appeal Board ruled in the Shoreham Proceeding, that the Vermont Yankee would indeed continue to **[431]** govern until a ruling is issued.

Mr. Freeman mentioned that ruling. But, I would like to point out a footnote to the Appeal Board Ruling, that goes to this point, Footnote 19, where the Appeal Board, in ruling on the questions that we are certified, states that, "Any rule which the Commission may adopt as a result of the current rule-making proceeding, may be made applicable as appropriate to this proceeding."

And, they cite various sections of the Atomic Energy Act, and also their own ruling in the Point Beach 2 Proceeding. So, we think it is very important and it is not in the rule now for this Board, and the Commission to focus on what provisions should be made for applying the rule which is finally adopted to the individual proceedings.

There have been a couple of points that have come up so far, that I would like to take a few minutes to respond to. Particularly as to Mr. Roisman's theory of this rule-making proceeding. As I understand it, what Mr. Roisman is asking for, is a generic proceeding on the entire fuel cycle.

And he defines, my understanding of his definition of generic is that it would be a total review of the entire atomic energy program, both with respect to the fuel cycle, and the construction and operation of the reactors, themselves.

I would like to note that having sat through yesterday's testimony, that, if indeed, this were an adjudicatory [432] type of proceeding, as Mr. Roisman would like to have, that most of the testimony would have been outside of the scope of the proceeding, since it did not relate, either to the substance of the alternative rules, or to the substance of the survey, itself.

The notice of the Commission is very clear, with respect to the scope of the proceeding, and had this been an adjudicatory-type proceeding, I am sure that much of the testimony offered, yesterday, would not have been permitted on the grounds that it would be outside of the scope of the proceeding.

I don't mean to suggest that we are objecting to Mr. Roisman and his technical experts taking the opportunities, which they have here to explore those broad issues.

We think that is perfectly consistent with the approach that the Commission has taken here, in establishing this rule-making proceeding. We think they ought to have an opportunity to raise all of the issues, which they think are relevant to this issue, and we think that the primary purpose of this proceeding is to establish that kind of a broad record which will aid the Commission.

So, I don't mean to suggest we are objecting to that. But, it does indicate that the Commission's approach, here, i.e., a rule-making proceeding, does have a great deal of merit. And it avoids all of the cumbersome, long, drawn-out [433] procedures, which would stand in the way in an inquiry such as this, of establishing a full and adequate record.
[434]

I would also like to note, since it sort of goes to the heart of Mr. Roisman's group's position, you will recall that Mr. Roisman said yesterday if the public had the facts, they would not permit the atomic energy program to go any further. He was speaking as a lawyer, I take it, since that is his professional position, but his technical expert, Dr. Radford, disagreed with him on the fundamental issue.

I wish to call that to the Board's attention, as to the need for the continuation of the nuclear fission program. Dr. Radford did indicate in his opening remarks that in their house they do not require unanimity of views on this subject, and he disagreed and he did think it was necessary to continue a nuclear fission program.

I would also like to note that Dr. Radford, in commenting on the Part 50 as-low-as-practicable proceeding, indicated that he thought the Commission went too far and imposed overly conservative criteria in that proceeding.

Now, his reason, I guess, was that they are so low they are not enforceable. Nevertheless, it is a recognition of the approach which the Commission has taken with respect to safety and environmental considerations, and truly a very conservative approach, and this was recognized by Dr. Radford in his testimony.

We see a little bit of this same philosophy [435] on environmental impact. My reading of NEPA and all of the relevant guidelines indicates that the responsibility of the government agency is to make a realistic assessment of environmental impact. Now what do we see developing, if you take the survey, you take the rulings of the Commission in individual proceedings, look at the detailed statements in those proceedings, you will see the Commission is indeed adapting their conservative approach with respect to safety issues to environmental issues.

I think that results in a much more conservative, more strict assessment of environmental impact than is required in NEPA. I just point that out because I think it does go to a determination of the seriousness with which the Commission is approaching its responsibilities in this area.

Mr. Roisman made another point which I think is worth commenting on. He said that the industry — he referred to the comments of Babcock and Wilcox, thinks that the material in the guide is conservative; nevertheless, they don't want it applied as operating standards, and that is true. I think that we have tried to make that clear in Mr. Wiggins' statement.

The survey is intended as an assessment of the generic impact of the fuel cycle. It has a model approach in there which results in facilities which cannot be designed, [436]

and which cannot be operated, but which result in very conservative estimates of environmental impact. It ought to be very clear, there should be no confusion in the Board's mind about our position on that. We would be concerned if anything in the survey would be construed as operating limitations, because that is not the purpose for which the survey was designed.

So we think Mr. Roisman has made a valid point here, and we think there is a valid reason for not considering these as operating limitations.

Now to get to what I understand is the heart of Mr. Roisman's position, which is that the Commission has made an error in adopting the rulemaking approach here, and that they should go to the adjudicatory approach with the full rights of cross-examination and discovery. Leaving aside whether or not this would be legally barred by NEPA, and I don't think it is, but let's leave the legal issue aside and look at the policy issue involved here, and I know from the discussion by the Board that they are well aware that the underlying policy considerations are broad.

If Mr. Roisman thinks he needs an opportunity for cross-examination and discovery, we think that he has a burden which he has not yet discharged in this proceeding, which is to demonstrate that information which he considers to be relevant and documents he considers to be relevant are [437] not available to him. I have heard nothing so far, and seen nothing in his written submissions so far which would indicate that Mr. Roisman has asked questions which will not be answered, or has asked for information which will not be provided.

Now we think the Commission has taken a reasonable approach in this rulemaking proceeding. We think they have

given this Board a great deal of flexibility with respect to the procedures, for the sole purpose of assuring that procedural arguments are not going to stand in the way of developing a full and adequate record. And we would hope on the basis of these two days of public hearing that whatever questions the Board may have, and whatever questions Mr. Roisman may have, will be asked, and each of the participants in this proceeding will make a serious effort to answer them.

Now if those questions are not asked, then we question whether or not Mr. Roisman has fulfilled his threshhold responsibility, which is to exhaust his remedies in this proceeding before he says that this is not an adequate way of assessing the environmental impact of the fuel cycle.

What is required here is not procedural due process, it is substantive due process. What is required is the compilation of an adequate record upon which the Commission can make a determination and then some indication on the part of the Commission that they have evaluated that [438] record. And we feel that if this Board discharges its function in compiling that record and if the Commission discharges its function in evaluating that record, that the results of this proceeding will be valid with respect to NEPA and will be upheld in the courts.

So we think that there is a very heavy burden on Mr. Roisman's group to demonstrate that this approach is not effective.

Finally, again to get back to the generic approach, Dr. Steindler, I believe, raised the question of whether these broad issues of national policy, in other words, the total atomic energy program, should be more appropriately considered in Congress or some other body — excuse me, the

Chairman asked this question — rather than before this Board.

Well, the Congress has looked at the atomic energy program at least twice in a very comprehensive fashion, when they enacted the Atomic Energy Act of 1946, and when it was revised and re-enacted in 1954. There is a public policy decision involved in those acts which is valid today, that indeed there is a national policy in favor of the atomic energy program. Congress looks at this again every year, in both the authorization and the appropriation proceedings.

So we think with respect to the overall atomic energy program, that this is not the proper forum for consideration of that broad public policy issue. We think [439] that has already been laid to rest by the Congress.

And we think that Mr. Roisman's interpretation of this to include both the reactor and the fuel cycle does not comport with what appears to be the intention of the Commission in what I think is a very clear statement in their Notice of Proposed Rulemaking.

Mr. Roisman raised a question about the interpretation of Alternative 2, which I must say I had not focused on before. His question was whether the words "shall be" in Alternative 2 indicates that the survey would be placed in the Staff's detailed statement and therefore be subject to cross-examination in the individual hearings.

It seems to be very clear to me what the Commission's intention is in Alternative 2, and it is not that, particularly when you read it in view of the Commission's rule of practice in Section 2.758. Section 2.758 says that a Commission rule which is validly adopted is not subject to attack in an individual proceeding.

In other words, you can't go behind the rule in an individual proceeding. The remedy is in a petition for rulemaking.

Now when you apply Section 2.758 to either Alternative 1 or Alternative 2, I think it is clear that it is not contemplated that there could be an attack in the individual proceeding on the validity of the rule or on the **[440]** validity of the survey which is a part of that rule.

Therefore, to get back to one of the questions I raised before, I think it is very important for this Board to focus on the precise impact which adoption of either of these alternatives would have in individual proceedings.

Mr. Chairman, I think that concludes the remarks we would like to make.

We would be happy to answer any questions the Board may have.

(The document follows.)

Discussion of Alternative Rules

The Commission has proposed two alternative rules for considering the nuclear fuel cycle in individual reactor licensing proceedings. Alternative (1), as published in the Federal Register, provides that with certain exceptions the environmental impact of the nuclear fuel cycle need not be included in the applicant's evironmental report or the Commission's detailed statement, "since the environmental effects of those activities as related to a particular light water-cooled nuclear power reactor have been analyzed (in the survey) and, *when* factored into the cost benefit analysis *are* sufficiently small as not to affect significantly the resultant conclusion". In response to the Forum's letter inquiry

of January 9 the AEC has stated that the word "if" should be substituted for "when" and "would be" for "are".

This clarification of the Commission's interpretation of alternative (1) is one of substance. Under the original wording, it appeared that in individual reactor licensing proceedings, the environmental impact of the nuclear fuel cycle would have been considered by the Commission in the overall cost-benefit analysis, even though not included as such in the environmental report and detailed statement. As modified, it is clear that the environmental impact of the fuel cycle will not be considered at all in individual reactor licensing proceedings, since it has already been considered in the survey and been found to be *de minimus*.

Alternative (2) provides that the environmental impact of the nuclear fuel cycle will be considered in the environmental report and detailed statement in individual reactor licensing proceedings on the basis of Table S-3 of the summary. Thus this alternative does provide for some consideration in individual reactor licensing proceedings of the environmental impact of the nuclear fuel cycle, *albeit* on a generic basis.

The National Environmental Policy Act, the Council on Environmental Quality guidelines and the AEC's rules in Appendix D, 10 CFR Part 50, all make it clear that cost-benefit analysis should contain a full and frank disclosure and consideration of the costs and benefits of the proposed action; however, as the Commission noted in the statement of considerations accompanying the proposed alternative rules, "The results of the application of this principle to the question of inclusion of environmental effects associated with the fuel cycle are not entirely clear." In fact, there is a wide division of opinion among those who have studied the alternatives as to which is to be preferred.

One group,* arguing in favor of alternative (1), states that this approach is consistent with NEPA and would simplify and reduce the scope of reactor licensing proceedings. Stating that alternative (1) as now proposed is "grounded on a conclusion of insignificance", the group makes certain suggestions for additional grounds of support for alternative (1); if so revised, the group would then invoke *NRDC* v. *Morton* as providing the legal rationale:

> "Obviously, the Commission does have authority to set limits to the scope of its environmental review. For example, as stated in *National Resources Defense Council* v. *Morton* (458 F.2d 827, 3 ERC 1558 D.C. Cir. 1972), only 'reasonable alternative courses of action' need be examined. The logic of the language in that decision applies equally to this rulemaking proceeding if the Commission finds that there are effects which 'cannot be readily ascertained' and which involve only 'remote and speculative possibilities.'"

Another group,** supporting, with some slight modifications, alternative (2) contends that "this alternative affords the greatest clearance over the high hurdles of the original *Calvert Cliffs* decision". The group also contends that alternative (2) is more consistent with the stress on systematic analysis and the encouragement of quantification found in *Calvert Cliffs* and Appendix D which requires that environmental reports and detailed statements include:

> "a cost-benefit analysis which considers and balances the (adverse) environmental effects of the facility . . . as well as the environmental, economic, technical and other ben-

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*Statement filed on January 15, 1973 by LeBoeuf, Lamb, Leiby and MacRae on behalf of eight utilities.

**Statement by Hunton, Williams, Gay and Gibson, filed on January 15, 1973 on behalf of fourteen utilities.

efits of the facility. *The cost-benefit analysis shall, to the fullest extent practicable, quantify the various factors considered.*"

The Regulatory Procedures Subcommittee of the Forum's Lawyres Committee studied both alternative rules but was unable to reach a consensus in favor of one or the other. For this reason, we are not here expressing any preference between the two alternatives, but would like to reserve the right to do so at a later date after the record has further developed the arguments on each side. We should also like to note that our inability to take a position at this time, along with the persuasive arguments which have already been developed on both sides, confirm the Commission's statement that the appropriate answer is, indeed, "not entirely clear" and places a heavy burden on this Board and the Commission to assure that the record is fully developed before a position is finally determined.

While not taking a position, we would like to raise a few questions for the Board's consideration. The first is the threshold question of whether both alternatives meet at least the minimum requirements of NEPA, the Council on Environmental Quality Guidelines and Appendix D. A second is the practical effect which each of the alternatives would have in individual reactor licensing proceedings, i.e., the burdens imposed on the parties by application of either alternative. The final question is the impact which the adoption of any rule would have on cases currently in the licensing process. We believe the Board and the Commission should seek further guidance on these issues before a determination is made in favor of either alternative.

In summary, we believe the Commission has a difficult task in choosing between these alternative rules and hope that this statement is of some help in its deliberations.

UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

In the Matter of	Docket No. 50-3
Environmental Effects of the Nuclear Fuel Cycle	

Certificate of Service

I hereby certify that copies of the statement of Edwin A. Wiggin, Executive Vice President of the Atomic Industrial Forum in the above-captioned proceeding, were served upon the attached list of individuals this 30th day of January, 1973.

George L. Gleason

Secretary (10)
U.S. Atomic Energy Commission
Washington, D. C. 20545

Max D. Paglin, Esq., Chairman
Hearing Board — ASLB
U.S. Atomic Energy Commission
Washington, D. C. 20545

Dr. Martin J. Steindler
411 Sandburg Street
Park Forest, Illinois 60466

Dr. John C. Geyer, Chairman
Dept. of Geography and
Environmental Engineering
The Johns Hopkins University
513 Ames Hall
Baltimore, Maryland 21218

John K. Restrick, Esq., Counsel
APED, Nuclear Energy
Division
General Electric Company
(M/C 304)
175 Curtner Avenue
San Jose, California 95125

Mr. John M. Arthur
Chairman of the Board and
Chief Executive Officer
Duquesne Light Company
435 Sixth Avenue
Pittsburgh, Pennsylvania 15219

Mr. Donald C. Lutken,
President
Mississippi Power & Light
Company
P. O. Box 1640
Jackson, Mississippi 39205

Mr. John W. Landis, President
Gulf General Atomic Company
P. O. Box 608
San Diego, California 92112

Mr. W. D. Rowe
Acting Assistant Administrator
for Categorical Programs
U.S. Environmental Protection
Agency
Washington, D. C. 20460

Professor Lawrence Ruby
College of Engineering
Department of Nuclear Engineering
University of California, Berkeley
Berkeley, California 94720

Mr. H. W. Brook, General Counsel and Secretary
Nuclear Fuel Services, Inc.
6000 Executive Boulevard
Rockville, Maryland 20852

Mr. Ken Dzugan, Research Scientist
Minnesota Pollution Control Agency
717 Delaware Street, S.E.
Minneapolis, Minnesota 55440

Mr. John D. Hoffman
Sierra Club Legal Defense Fund, Inc.
311 California Street
San Francisco, California 94104

Michael I. Miller, Esq.
Partner
Isham, Lincoln & Beale
1 First National Plaza
Suite 4200
Chicago, Illinois 60670

Mr. Steven J. Gadler
2120 Carter Avenue
St. Paul, Minnesota 55108

Mr. Jack C. Fensterstock
Teknekron, Inc.
1619 Massachusetts Avenue, N.W.
Washington, D. C. 20036

George L. Edgar, Esq.
Morgan, Lewis and Bockius
1140 Connecticut Avenue, N.W.
Suite 1100
Washington, D. C. 20036

Mr. Richard H. Stroud
Executive Vice President
Sport Fishing Institute
608 Thirteenth Street, N.W.
Washington, D. C. 20005

Anthony Z. Roisman, Esq.
Berlin, Rosiman and Kessler
1712 N Street, N.W.
Washington, D. C. 20036

Mr. Robert A. Wiesemann
Manager, Plant Safeguards & Licensing
Atomic Power Division
Westinghouse Electric Corporation
P. O. Box 355
Pittsburgh, Pennsylvania 15230

Mr. W. Donham Crawford
President
Edison Electric Institute
90 Park Avenue
New York, New York 10016

Mr. R. L. Dickeman, President
Exxon Nuclear Company, Inc.
777 106th Avenue, N.E.
Bellevue, Washington, 98004

George C. Freeman, Jr., Esq.
Hunton, Williams, Gay & Gibson
700 East Main Street
P. O. Box 1535
Richmond, Virginia 23212

Dr. Leonard Geller
Vice President - Research
The S. M. Stoller Corporation
1250 Broadway
New York, New York 10001

J. Bruce MacDonald, Esq.
New York State Department of Commerce
New York State Atomic Energy Council
112 State Street
Albany, New York 12207

Mr. Samuel R. Madison
New York State Atomic
Energy Council
N.Y. State Public Service
Commission
44 Holland Avenue
Albany, New York 12208

Mr. Terry R. Lash
Natural Resources Defense
Council
36 West 44th Street
New York, New York 10036

Mr. Arnold R. Fritsch
Gulf United Nuclear Fuels Corp.
Grasslands Road
Elmsford, New York 10523

Mr. Franklin L. Gage
27 Hastings Avenue
Croton-on-Hudson, New York
10520

[441]

CHAIRMAN PAGLIN: Thank you, Mr. Gleason and Mr. Wiggin.

Dr. Steindler.

DR. STEINDLER: I gather that the Forum endorses the generic approach. Other than potential convenience, why do you favor it?

MR. GLEASON: Dr. Steindler, the Forum, through its environmental committee has done a great deal of work on AEC's environmental reporting requirements, and as you know, a draft guide has been out for a number of months and a final guide will be coming out in the near future.

Our work on that guide has made us realize that there are a number of aspects of the environmental impact which indeed are common to many facilities. And to try to take a subject which is generic and to consider it in the context of an individual reactor proceeding, it simply does not make sense.

We think that we are in a new area of environmental reporting here, we think we are sort of in the model, the stage of the development of the state of the art, and we think the

generic issues ought to be sorted out and considered on a generic basis.

It is more than a question of convenience, it is a question of the best way to evaluate impacts which are generic and you can't do that as adequately in the context [442] of an individual proceeding as you can in a broader generic type proceeding.
[443]

DR. STEINDLER: There was a comment on uranium mining, and I am reading from the text that I have, you say, "We question whether any land is permanently committed," and then you discuss land reclamation processes, and whatnot.

Do you propose then, a rather more restrictive definition of permanent commitment which, in effect, says, that unless you have got very long-lived fission products you are burying someplace, there is no such thing as permanent commitment?

And, then to put a second question to you, if that is your intent, are you recommending that that part of the document which speaks of permanent commitment, not only in mining, but in the analysis of other facilities, ought to be revalidated?

MR. WIGGIN: I think the definition you cited is a fair one. It seems to go along the trend followed, being followed at the State and Federal level in legislation; and, indeed, if it is going to be returned to its natural state, at such time as the activity, whatever it may be is terminated, then I guess I think it has not been permanently committed.

DR. STEINDLER: I don't want to get involved in the same discussion I got into, earlier, about the philosophical

concepts of permanence, and I appreciate Mr. Murray's concern about coming to grips with the real issues rather than philosophy.
[444]

But it does make, obviously, a difference to the magnitude of the impact if you assign a certain number of acres of territory or something to be permanently out of bounds for society's use? Now, you can break up concrete, and bury it, if concrete is the only thing you have there.

You have a little more problem if the concrete is contaminated with long-lived, fission products. But, is it then your position that any facility, that you can, in effect, disassemble or move or dispose of, in some fashion, short of being contaminated with long-lived activity, it represents, perhaps, an interim commitment of resources or land, but not a permanent commitment of resources or land.

Is that your position?

MR. WIGGIN: Yes, sir.

MR. MURRAY: Dr. Steindler, I think you misread me a little bit, I don't want the record to reflect that, if I may. I think these are exceedingly important philosophical issues we are dealing with here, and they ought to be dealt with, and dealt with very carefully.

What I was suggesting, was the adjudicatory process is not the proper process to deal with philosophical issues, but, rather, the rule-making process. The adjudicatory process is for getting at facts, and we have not had any factual disputes presented.

DR. STEINDLER: I see. I am sorry for the **[445]** misinterpretation. In your testimony, you brought up, as you say, the whole question of mine tailings, and their use.

I wonder if we can identify or you can identify, for us, who, at the time the mine tailings were, in fact, used, in the Grand Junction area; who had jurisdiction over the licensing?

Are we talking about something that the Commission, as then constituted had jurisdiction over, or was this outside of the Commission's licensing activity?

MR. WIGGIN: It is my understanding we got into the problem because nobody had jurisdiction. or nobody exercised authority. The AEC did not have that responsibility, and apparently, the state, in this instance, did not exercise any responsibility or authority.

DR. STEINDLER: Is it possible to move from this witness to the Staff witness?

CHAIRMAN PAGLIN: Surely.

DR. STEINDLER: Mr. Smiley, could you comment on that?

MR. SMILEY: I think Ed is largely correct. The responsibility was not the AEC's. It, technically, was the state's. The Act says that any material that contains less than five hundredths of a percent uranium is not under the jurisdiction of the AEC.

I might point out that stuff like fertilizer is .01 or .02 of a percent. That is one of the reasons I am [446] sure they went into that. So the fact of the matter is AEC had no jurisdiction. There is a letter by Harold Price in this regard in 1961.

DR. STEINDLER: Then, I can assume, bringing up that particular issue does not have a direct bearing on our problem of the environmental impact as treated by the Division of Licensing?

MR. WIGGIN: That is a correct assumption. I raised it simply because I thought it would be raised by others and indeed, it was.

DR. STEINDLER: Yes, in the area of hexafluoride production, you indicated there is a problem of averaging-out two very different plants, and you then, in the second paragraph of that particular topic, I think, are making a suggestion of an averaging process, but I fail to see quite what it is that you are suggesting.

Let me couch the question in this way: Are you suggesting that, in order to revise or make more accurate, the survey documents, that an analysis be done of the two processes that are involved, and impact definition be defined for both of those processes, appropriately summed, and then averaged?

MR. WIGGIN: No, sir. I did indicate, and I do believe the credibility of the model approach — not only in this instance, but across the board — would be enhanced if indeed, there were some real measurements of the upper and [447] lower limits to show where in its numbers generated in the model, fit.

In this particular instance, what I am trying to say is, if you know which plant was used to produce a given amount of uranium hexafluoride, by deifnition, you know the kinds of effluent released, and therefore, you can go to the survey report, and presumably assume that all of the effluent of that particular type, whether it be solid or whether it be liquid, came from that particular plant.

In other words, I think there is a way of backing into the environmental impact of each type of plant, because they are so different, and because the AEC has assumed that 50 percent of the product will be produced in each.

DR. STEINDLER: As you relate this then, to a particular reactor, in order to keep track of the "Blue" UF-6, that has been produced in the Blue Plant —

MR. WIGGIN: I am not suggesting that.

DR. STEINDLER: Are not you going to require the defusion process not mix the uranium coming from this particular plant, and then that enriched uranium be identified as attributed to a particular reactor?

MR. WIGGIN: no, I am not suggesting that. The intents of the paragraph was a search on my part to provide a backdoor approach to credibility of the model result.

DR. STEINDLER: You indicated, and I think, quite
[448]
correctly, that the quantity of high level liquid waste should be escalated above what is in the report. But, if my memory serves me right, liquid, high-level wastes stored for an interim period do not represent, since they have to be consequently treated, and converted to solids, which are consequently shipped to the repository, do not represent a prolonged environmental impact, that is, a prolonged environmental concern.

I presume that your comments on the volume of high-level waste is simply a matter of keeping the factual aspects of the report in order?

MR. WIGGIN: Yes, sir, you are absolutely right.

DR. STEINDLER: I believe that is all I have.

CHAIRMAN PAGLIN: Dr. Geyer?

DR. GEYER: Mr. Wiggin, on page eleven, under the plutonium recycle, the last paragraph makes the suggestion that the health and safety problems would be mini-

mized by recycling plutonium to theextent practicable, or reducing the turnaround time to the minimum possible.

Perhaps, not now, but consequently, could data be given on what you believe to be the minimum turnaround time, how much this would reduce the inventories that might need to be otherwise held, what the problems would be associated with taking this suggestion?

MR. WIGGIN: You are quite right. I cannot answer that. I would be very happy to submit a written answer to it, [449] or attempt to.

DR. GEYER: On page 13, the paragraph at the top of the page discusses some things that you feel need to be done with respect to the survey report.

Could you amplify, not now, but in future communications, could you amplify in detail, what you think needs to be done?

MR. WIGGIN: Yes, sir.

DR. GEYER: My last question is to Mr. Gleason and I don't know whether I am the proper person to ask this question or not, but on the last page of the testimony, page 15, several questions are asked which Mr. Gleason partly answered, but also backed off from answering them, because he was at that time, representing the Atomic Industrial Forum.

Since he is a lawyer, and an individual, can I ask Mr. Gleason, what his answer is as a person to these three questions would be.

The first one: Do both alternatives meet the minimum requirements of NEPA on environmental, quality guidelines, and Appendix D?

MR. GLEASON: Dr. Geyer, I was afraid you were going to ask that.

CHAIRMAN PAGLIN: If he didn't I think either Dr. Steindler or I would have.

MR. GLEASON: You have presented a very tempting [450]
proposition to me, obviously, because as a lawyer, and an individual, I do have some views with respect to the answers to those questions.

However, I cannot completely disassociate myself from my position as the Staff counsel of the Atomic Industrial forum, and also my position as the Secretary of the Lawyers Committee.

And, I think that it would not be appropriate for me to indicate what my personal views are: first of all. Secondly, these are fairly serious issues, and we have looked at them in this lawyer's group. We have not really solved what our position is on all of them. We anticipate that there are going to be further discussions and considerations of these issues.

I would hope, before the record in this proceeding is closed, that either through the Forum, or through the submission of individual parties in this proceeding, that the answers to those questions will be a great deal clearer than they are today.

So, we would undertake to provide you with additional guidance on this subject.

DR. GEYER: That would be adequate, I believe.

CHAIRMAN PAGLIN: And, would you, Mr. Gleason, if I may interrupt, direct that guidance in the areas of what you think would be the practical effect — you referred to the, [451] "practical effect of the adoption of either Alternative One or Two," and likewise, so long as we are throwing darts at you, you made reference in your comments to

the question of the commission's rules and the impermissibility of attacking the validity of a rule in an individual licensing case, and that is a general purpose of administrative law.

How would you suggest, for example, the most practical and effective way for the participant to question the validity of the data, the matter to which I referred in my discussion with Mr. Roisman, what do you feel would be the most practical and efficient way of having questions raised as to the validity of the data in the survey.

Because, if I believe what you say is true, and what he says is true, this would be the Forum where that would be done.

It that correct?

[452]

MR. GLEASON: That is right. I think Section 2.458 contemplates that someone objecting to a rule does not have a forum, but what it does is indicate the appropriate forum is a petition for rule-making, in accordance with, I believe, 2.802, and that the rationale for that is that the rules of general applicability have a broader impact than can be adequately assessed by the parties in an individual proceeding, and therefore, if the validity of a general rule is going to be attacked, it ought to be attacked in a forum, where all interested parties have an equal opportunity to participate and that would be in a rule-making proceeding.

CHAIRMAN PAGLIN: Right. But I am slicing that a little thinner, looking for an effective procedure by which in the rule-making proceeding the parties could raise questions as to the validity of facts.

As I indicated to Mr. Roisman, I personally do not feel that the labels are so holy — and I think the courts feel the

same way about it, they have indicated that a rose by any other name, that whether you call it rule-making or not, there needs to be a valid basis for the agency's action. And, if, in fact, the data base or the facts upon which the agency purports to act are not valid, you have got to give the participants an opportunity to address that question and whether you do it by some other kind of procedure within the rule-making, I think remains open [453] to ingenuity, the authorities in the field have various suggestions, the Administrative Conference, at its last plenary session, had a recommendation having to do with "Rules of General Applicability," and they made some suggestions as to how these difficult problems should be approached. I would hope this might be a vehicle whereby we could assist the Commission in that regard.

MR. GLEASON: I can partially answer your question right now. I don't think it is necessary as part of the rule-making proceeding on subjects such as this to have full rights of cross-examination and discovery. I do think, as you indicated, that it is necessary to provide a forum for development of a full and adequate record. There are other ways that can be more expeditiously accomplished, when you are talking about matters, sophisticated matters of science and technology, involving scientific and technological facts.

I think Dr. Steindler has suggested one alternative. The Forum Lawyers Committee issued a report in October 1970 considering AEC licensing procedures, and we recommended in that report — I would be happy to supply it for the record — that the Commission explore procedures such as this one being held now. We think there is a wide range of procedural rights that can be afforded to parties in rule-making type procedures without getting into full adjudication, which we believe often stands in the way of compiling

an [454] adequate record. I think Mr. Roisman is espousing a position which is consistent with administrative law which grew up in the 1930s. This was the classic approach to quasi judicial proceedings. But in the 30 or 40 years since then, we have learned a great deal, we are a much more sophisticated technological society today, we find the rules of common law and administrative procedures do sometimes stand in the way of compiling an adequate record. We think the Commission has given this Board the flexibility to compile the kind of a record which would be necessary in order for them to have the information before them that they need to make a reasonable judgment on the alternatives.

We don't think it is necessary to go back to the traditional cross-examination and discovery route, and we particularly don't think so until you have exhausted all of the possibilities within the confines of this particular proceeding.

CHAIRMAN PAGLIN: This is what I was referring to earlier, Mr. Gleason. I would repeat again I would hope the participants would come forward with specific suggestions as to available procedures.

Dr. Steindler?

DR. STEINDLER: I have one more question. There was some major emphasis placed on the notion that the description of the fuel cycle in its individual pieces and [455]
plants not become an operating limit. In the light of alternatives 1 and 2 and the use to which that document or its sons and daughters is going to be put, how would you justify or what reason do you give to avoid placing an upper limit on, say, the discharges from a, for example, a UF-6 production facility, which are, in effect, those that are

given here, recognizing that the range of impact, local impact, of a particular plant, obviously exceeds the averages in both directions, but it is the upper one that people are generally concerned about.

MR. GLEASON: I think Mr. Wiggin will want to respond with respect to the technical considerations, but let me just say this, that you don't use a butcher knife for heart surgery, because it wasn't designed for that purpose.

We were not objecting to the establishment of designs for operating limitations. Such conditions are in the license conditions and regulations. We don't object to that at all. But when your approach is to, as a model approach, with the objective of getting an overall assessment, a generic assessment of the environmental impact, those numbers are arrived at for an entirely different purpose, and they are not designed with the objective in mind of establishing operating limitations.

Let me emphasize, we don't object to operating limitation, but we object to taking numbers that have been
[456]
developed for a generic environmental impact statement and applying those particular numbers as operating limitations. It goes right to the heart of the model approach in the survey. If you take the model light water reactor there, as Mr. Wiggin pointed out, it is part PWR and part BWR. You can't design that reactor, therefore, you can't establish those operating limitations on it, because you just can't design it. So it is just a question of making sure we understand the purpose for which the numbers were put together in the survey, if they are and that they are used for that purpose.

MR. WIGGIN: I don't think I have anything particularly to add to what George said, other than to emphasize that if

your end objective is to establish operating limits for a specific, identified facility on a specific site, I simply don't think you go starting from here. You simply wouldn't use a model approach.

DR. STEINDLER: Let me ask the second question. If this document were to be provided with a, as has been mentioned and suggested, perhaps, a few times, with not only the model performance on the environment, but also the range of either current practice or the range of numbers used for any particular emission or what have you, would you consider the upper limit of that range, upper presumably also meaning the most severe environmental impact, as being representative of an upper limit to the actual operation of [457] any specific plant?

MR. WIGGIN: I am not sure you can make a generalization. I am not sure I would agree to that on a generalized basis. I think you would have to look at each individual, at least, each individual step in the fuel cycle to see if, indeed, that would work, and, indeed, it would, I think, call for a more severe test of the model approach, the way the numbers have been generated, the assumptions used and than, I think, perhaps has been done by anybody other than by the AEC staff up to this point in time.

MR. GLEASON: We don't mean to suggest that you — necessarily suggest that you can't establish operating limitations on some broad, perhaps, generic basis. I think that Appendix I proceeding was an effort in that direction.

I don't wish to comment on the merits of that, but it may be possible to take that approach to the establishment of operating limitations.

But you have to start with that objective in mind and develop the numbers with that objective in mind, and those

are not the numbers in the survey. That is why we would object to it being considered as such.

DR. STEINDLER: You understand all I am trying to do is put into the record for someone else to review a scope of potential points that may well be raised or should be raised in connection with the study. That is all I have.

[458]

CHAIRMAN PAGLIN: Mr. Gleason or Mr. Wiggin, do you have anything further?

MR. WIGGIN: No, sir.

CHAIRMAN PAGLIN: We thank you for your presentation.

Off the record.

(Discussion off the record.)

[459]

CHAIRMAN PAGLIN: On the record.

May we resume?

Before we commence with Mr. Freeman, Dr. Steindler has some comments.

DR. STEINDLER: These are comments for the record, more than anything else. But I think they are probably addressed to the world at large as well.

It seems to me that the course of the questions and discussion we have had here could possibly lead somewhat to misinterpreting what these hearings are all about. The topic of discussion here is only a very small part of the total environmental statements that are prepared for all aspects of the fuel cycle.

I presume it is made eminently clear to the public, the press, the participants here, and anybody else, that for each

facility under license is prepared in excoriating detail and great analysis an environmental impact statement which is subject to review, analysis, and I am sure severe argumentation, both among the Staff itself and with the owner of the facility and whoever else, possibly including Intervenors, and that this particular statement is not designed to take the place of those, at least certainly as I understand it, and I think that is correct, and this is simply in addition to that part which is applicable to the reactor aspect.
[460]

I don't know if that has come through clearly or not, but a portion of the discussion, I think, has been leaning toward the notion we are trying to replace the environmental impact statement. I don't think people ought to walk out of here with that impression, should they hold it.

CHAIRMAN PAGLIN: Thank you, Dr. Steindler.

VOICE: May I ask a question? I am not with any organization, I am just one of three billion people that are a little bit tired of the simian-type mentality among the scientists, people who call themselves scientists.

Now there is something, solar power, that has been done in France. Now I understand that the whole thing —

CHAIRMAN PAGLIN: Excuse me, madam —

VOICE: I am just going to say about three more words, and that is that everything is get up a little steam, to run a turbine engine to create electricity, that is it, just to get up some steam, isn't it, the whole thing simplified, that is it. Yet there is a solar power thing in France that gets up 7000 degrees Fahrenheit, which certainly would boil a little water to get a little steam.

CHAIRMAN PAGLIN: May I ask you to hold your remarks? At the beginning I indicated when we completed

our proceeding, if there was anyone who felt it desirable to make additional comments, we would be glad to call upon them. So if you will do us the courtesy of abiding by that [461]
procedure.

VOICE: That is my total comment. I thought you were going to just fluff the rest of the people off.

CHAIRMAN PAGLIN: No, that is not our intention.

I started to make a comment of appreciation to Dr. Steindler for his remarks, but I wanted to note in point of time that none of the members of the press were here at the time. I would hope to the extent that Dr. Steindler intended his remarks for the members of the press who were sitting here, perhaps when we are through, they can be advised of what it was he said, which I think is quite significant and quite important.

Well, may we now commence Mr. Freeman's presentation?

STATEMENT OF GEORGE C. FREEMAN, JR., BALTIMORE GAS & ELECTRIC COMPANY AND OTHER NAMED UTILITY COMPANIES APPEARING JOINTLY.

MR. FREEMAN: Mr. Chairman, the fuel cycle survey is an important first step toward the comprehensive assembly of information on the incremental environmental effects of nuclear power plants over the whole range of the nuclear fuel cycle.

As a practical matter, the information assembled there has not been previously available for use in the overall analysis of the environmental effects of individual reactors. We are confident that the survey will be corrected, [462] improved and supplemented as a result of this rulemaking,

and further supplemented from time to time in light of the rapidly emerging technology in the nuclear industry.

Issuance of the fuel cycle is important for yet another reason. It represents a further implementation of the Commission's sound policy begun in the ECCS and the as-low-as-practicable rulemakings of treating generic issues generically, rather than permitting the redundancy and indeed risking the inconsistency inherent in their piecemeal consideration in individual licensing cases.

This is sound administrative practice. It follows the recommendations of the Council on Environmental Policy, and indeed the recommendations of many of us who represent the industry and many who represent the environmental movement.

And as pointed out in detail in our letter of January 15, proceeding in this generic way is legally permissable.

As to the amendment of 10 CFR Part 50, we believe that the adoption of Alternate 1 as stated in the original Notice of this proceeding, or as restated by the Staff, is legally permissable if the essential factual premise upon which it is based is sustained by the final complete record of this proceeding.

That premise is that in every instance the **[463]** incremental adverse effects of a proposed reactor on those portions of the nuclear fuel cycle considered in the survey will be so small that they would not alter the overall balance of costs and benefits for the nuclear plant mandated.

As far as existing plants or plants that are proposed and currently in licensing proceedings are concerned, as far as we know, that appears to be abundantly clear, and indeed as far as we can see in the future, that should always be the case.

But that hypothetical question would be completely eliminated from this proceeding by adoption of revised Alternate 2 as set forth on page 10 of our January 15 letter. For that and the other reasons set forth in our letter, we accordingly believe that the optimum result would be to adopt the basic approach of Alternate 2, restated as we have restated it there, to make three things clear:

First, that Applicants' environmental reports and Staff detailed statements need not repeat the matters that would be covered in the supplemental fuel cycle survey.

Alternate 1 makes that clear right now. We think Alternate 2 should make it equally clear.

The second major clarification would be that the survey will be revised and supplemented from time to time to reflect substantial changes in the evolving technology or other important new information which may come to light in
[464]
this rapidly changing field.

And third, the survey as revised and supplemented would be deemed to be incorporated by reference in all such reports and statements.

The restated Alternate 2 as set forth in the letter is somewhat lengthy, and I will not take the time of the Board to repeat it here. Copies of our letter have been made available to the press, they have been served on the other participants, and if any member of the public would like copies of the comments and the restated Alternate 2, we would be glad to supply them.

The statements made by the spokesmen for EPA yesterday strengthen our preference for revised Alternate 2. As the record now stands, it is not clear whether EPA favors unrestated Alterate 1 or restated Alternate 1, and even if

EPA favors Alternate 1 in its original form as it appeared in the notice in the Federal Register, it is not clear whether EPA regards it or reads it as requiring that the incremental adverse environmental effects of a particular reactor on those phases of the uranium fuel cycle discussed in the survey be given zero weight when included in the cost-benefit analysis for a reactor.

Mr. Rowe stated at page 162 of the transcript that, "Adoption of Alternate 1 would not foreclose us the opportunity to consider all aspects of the fuel cycle [465] on a particular environmental impact statement when it comes up."

It was not clear whether Mr. Rowe thought this would include discussion of the generic issues of the uranium fuel cycle that we have at issue here, or whether we would have to come up with actual numbers from the generalized ones given in the survey.

Finally, Mr. Rowe's statement at transcript 154 that EPA does not entirely concur with that section of Alternate 1 of the proposed rulemaking that states, and he quoted from the Alternate 1, "Since the environmental effects of those activities as related to a particular light water cooled nuclear power reactor have been analyzed in the Commission's environmental survey of the nuclear fuel cycle and when factored into the cost-benefit analyses, are sufficiently small as not to affect significantly the result of the conclusions."

That is the close of the quote from Alternate 1, and from Mr. Rowe.

Now unless his comment and EPA's position is clarified, such a statement in the record will tend to undermine the essential finding of fact that would be necessary to the

Commission's adoption of Alternate 1, and that is, as we have noted earlier, that in all instances of all reactors, the incremental environmental effects discussed in the survey
[466]
would, if factored into the cost-benefit analysis, be de minimus.

While EPA continues to insist that NEPA does not apply to it, AEC is under no such delusion. The AEC, the industry it regulates, particularly the utilities and utility consumers, simply cannot afford another one or two-year moratorium on nuclear licensing in the near future. Since we must assume that the Calvert Cliffs decision remains the law and since it has language in it that speaks in terms of quantifying effects to the fullest extent possible, we believe our restated Alternate 2 removes any possible question as to compliance with the severe directives of that opinion, and thus offers the safest way for the Commission to proceed.

Yesterday and today Mr. Roisman indicated that he was in accord with a basic approach to regulation that many utilities and many environmentalists like himself have urged on AEC, and that is to remove these generic issues, such as uranium fuel cycle, from individual licensing cases and deal with them in a single generic proceeding.

But it is apparent from the discussion of yesterday and today that there is a fundamental difference between him and us as to the procedures which the Commission is, first, legally obligated to follow, and second, that even if not legally obligated, as a matter of sound administrative policy, should follow.
[467]
Let me make it clear that we believe that the purpose of this rulemaking is to afford the generic forum for the dis-

cussion of the generic issues raised in the survey, just as the ECCS and the as-low-as-practicable rulemakings have afforded the generic forums for the discussion of those generic issues.

If, as a result of this hearing, the AEC adopts any of the versions of Alternate 1 or Alternate 2 that have been raised on the record to date, then the effect will be to remove debate of those major generic issues from individual licensing cases.

The effect of Alternate 1 would be to remove any reference to them in those proceedings. Alternate 2, on the other hand, would bar using those forums of individual licensing cases as the place to debate the generic issues.

That should be discussed here. It would, however, leave the question of the applicability of the ultimate findings of this rulemaking open for the limited inquiry as to their applicability to the particular plant in much the same manner that we now permit limited discussions of the applicability of the ECCS interim criteria on Appendix I to such proceedings.

To grossly oversimplify what we have in mind, if we are talking about a 2000 megawatt plant, we have obviously got to take the generic information that will be reflected
[468]
in the final revised version of the survey and factor it up because it will there be shown only for a typical 1000 MW reactor. We do not agree with Mr. Roisman in his legal conclusion that NEPA or APA requires that interested individuals must be given rights of formal discovery, oral cross-examination and other presently recognized adjudicatory rights in at least one AEC forum, either in the plant

licensing proceedings or in the generic proceedings on every relevant question of fact or policy involved in the construction of a nuclear facility.

Such a position ignores the essentially dual nature of regulatory commissions such as AEC, as both quasi-judicial and quasi-legislative bodies.

If accepted, it would inevitably lead to the complete judicialization of the regulatory process and it would really turn the AEC into a specialized court which would be essentially similar to the Tax Court or the Court of Patents Appeals. We do not believe that Congress ever intended such a result when it enacted the Atomic Energy Act, APA, or NEPA.

Turning to what should be sound administrative policy, we believe, as we stated in our letter of January 15, that some means should be provided in generic proceedings, whether they are called adjudications or rulemakings, for enabling those concerned to raise legitimate questions of fact [469] on the record and for seeing that adequate answers to those questions are obtained on the record.

The position we are taking here at AEC is consistent with the position members of our industry have taken at EPA. We are ready, willing, and able to do whatever we can to see that Mr. Roisman and his clients and all of the participants here are able to obtain answers to valid questions on the record here. I repeat that.

We hope that we will receive like assistance when it comes to EPA rulemakings from them. Where we differ with Mr. Roisman on this subject is that we believe there are several ways in which this major substantive result can

be obtained. The formal adjudicatory techniques of discovery and oral cross-examination provide one way of obtaining that result. But there are other ways.

One is the method we recommended to the Board in our letter of January 15, and I might say that I think the Board at the prehearing conference on January 17 adopted the substance, if not the form, of that recommendation. It has clearly indicated on the record there, and in the two days that we have had these proceedings here, that participants could and indeed should raise all of the questions they have concerning the matters at issue here, in their written or oral statements. And the Board has indicated it will assure that the questions it regards as germane to the [470] issues here are answered in one way or another on the record that is eventually transmitted to the Commission.

Indeed, the Staff has indicated it will have its experts on hand to answer all of the Board's questions throughout this proceeding and the Board has also urged that other participants here with specialized knowledge be similarly prepared to respond to its inquiry.

Dr. Radford and Dr. Kendall yesterday raised some such questions on the record. We believe it is incumbent on them now to test the procedures available to it in this rulemaking before they may legitimately complain about their adequacy. They have asked a number of questions already. If they have remaining questions in mind, it is incumbent on them to raise those questions immediately, while the means for obtaining answers through Board questioning of participants is at hand.

The adequacy of the procedures afforded here for obtaining an adequate record for the Commission, or indeed court

review, should be tested concretely rather than being complained of theoretically.

Mr. Roisman has indicated he will brief the issue, and if so, we will be glad to reply to it.

Meanwhile, however, we believe it is incumbent on him to utilize the practical procedures available to him now.
[471]

As to substantive matters, the Board yesterday in its questions, and the participants in their written and oral statements, have raised questions of fact that should be answered on the record, and those answers should be subsequently factored into a revised survey.

To aid the Board in seeing that the record is complete, we intend to review it, including all of the written comments yet to be received from CXI, and that raises another problem we would like to discuss with the Board later, and point out those written comments which, in our opinion, require further discussion on the record. We believe that other participants should do the same, particularly if they intend hereafter either at the Commission or in a court review to claim that the record is inadequate because certain questions were not addressed.

After the Board has reviewed these questions, whether submitted the first time or pointed up in the second submission of the various participants, and fully re-examined the state of the record, if it believes that the record does not reflect an adequate answer to these questions, it should, as it indicated at the prehearing conference, schedule additional days of questioning of the Staff or such participants as it deems necessary to assure a complete and thorough record.

The Staff has already assembled a significant [472] amount of information in the survey. They have their witnesses here. We are confident that under the Board's guidance they will do whatever is necessary to see that the substantive right to full inquiry and to a full and complete record will be assured in this rulemaking.

That concludes our oral statement.

CHAIRMAN PAGLIN: Dr. Steindler?

DR. STEINDLER: In keeping with my comment before you started, you indicated that the Applicants need not repeat the matters that are already covered in the survey, and I think I ought to re-emphasize that those are the Applicants for a reactor license, and not the Applicants for a reprocessing license, or UF-6 production license.

MR. FREEMAN: Yes, sir.

DR. STEINDLER: On a perhaps more substantive matter, you indicated that this is basically a genetic forum —

MR. FREEMAN: Generic forum.

DR. STEINDLER: Oh, I'm sorry.

MR. FREEMAN: My southern accent sometimes —
(Laughter.)

DR. STEINDLER: I will assume that that is my hearing that is at fault.

Okay, generic. Since the proceedings cover many parts, or at least are easily divisible into many parts, and one method of division represents the various aspects of [473] the fuel cycle, are you suggesting one way to arrive at a satisfactory record which could stand as a technical base to be used for the environmental purposes of the reactor li-

cense hearings would be to hold generic hearings on each separate issue, in other words, on the mine and on the mill, and on the UF-6 production site, and on the fabrication site plant and so on? And in order to arrive at what might not be a continuously contested topic, clear the technical record in that kind of a proceeding? Or am I extending what your thoughts were beyond reason?

MR. FREEMAN: I think the basic purpose, as set forth in our letter of the 15th, of this proceeding, as we view it, is to compile what will be an accurate and fairly complete technical document for incorporation by reference into the environmental statements to individual power plants.

We think that is clearly within the interpretation of NEPA, which permits agencies to incorporate by reference not only their own internal reports, but scientific treatises.

We thing that that is the basic purpose of this proceeding, to compile the technical record on the incremental adverse environmental effects that construction of a nuclear reactor will have on those portions of the entire uranium nuclear fuel cycle which are currently outside current licensing proceedings, and which are covered in the survey.

DR. STEINDLER: That is all I have.

[474]

CHAIRMAN PAGLIN: Dr. Geyer, do you have some questions?

DR. GEYER: No questions.

CHAIRMAN PAGLIN: I have a question or two, Mr. Freeman.

You made reference to the criticality of the position of EPA and Mr. Rowe's testimony.

MR. FREEMAN: Yes, sir.

CHAIRMAN PAGLIN: Do you recall that I brought to his attention the fact that he was basing, or at least I thought he was basing his position in terms of the language before it was amended, and I read to him, I think Mr. Murray agrees it should have been read to him, the amended language? For the record, it appears on pages 162 through 164 of the transcript. And I asked him whether or not with the new amended language for Alternative 1, it would change the position of the EPA with respect to their comments, and in all fairness, he said he didn't know, he would have to take some time to consider it, and would come back if it changes anything.

I take it from what you told us that we should, if not await, at least request some statement by EPA as to whether or not this changes their position in any regard?

MR. FREEMAN: Yes, sir. I think it is very important that EPA clarify on the record just what it is [475] advocating when it advocates Alternate 1.

And secondly, I think it is also important that they think through and clarify the implication of the statement which appeared in his prepared testimony which raised some doubt in my mind, anyway, as to whether or not they agreed with the underlying factual premise which I feel it would be necessary for the Commission to find, substantiated by the record here, if it were to adopt Alternate 1.

So I think EPA needs to clarify its position in two regards.

CHAIRMAN PAGLIN: I would hope that this portion of the transcript, Mr. Murray, could be called to Mr.

Rowe's attention specifically, and see if he can't give us a response.

MR. MURRAY: We will undertake to do that, Mr. Chairman.

CHAIRMAN PAGLIN: Thank you.

One further question, Mr. Freeman.

In speaking about the available procedures as contrasted with Mr. Roisman's position, do you contemplate or is it within your contemplation and as part of a "rulemaking type hearing" that if the need arose, you could actually use the particular techniques of, let us say, what would otherwise be an adjudicatory case?

In other words, within your proposition, do you [476] conceive of the possibility of the Board or the Commission permitting what appears to be at least an adjudicatory type proceeding with some cross-examination in order to determine the validity of certain facts in a limited sphere?

MR. FREEMAN: Yes, sir, I think it is completely within your discretion. I would think that the kinds of situation where I would think limited oral cross-examination might be useful to the Board would be if there was, through written inquiry or through written questions and answers or responses, there was still doubt pinpointed into crucial questions of fact where the Board felt that the right — the Board itself — to orally examine a witness or indeed to give the participants the limited right to orally cross-examine a witness on a specific subject, to find out a question of disputed fact, that that would be entirely appropriate.

I think before anyone could complain that they were prejudiced from a due process point of view by the pro-

cedures followed here, when coupled with the overall scheme of commission regulation, which would not permit them in individual licensing cases to pursue such a line of inquiry through adjudicatory techniques, I think it would be incumbent on them in this proceeding to pinpoint the areas where they believe that such questioning would be essential to assure an adequate and complete record and if they are failing to do so, I think that just makes that — I think they would have waived [477] any right they might have.

CHAIRMAN PAGLIN: Here again — you don't have to respond to this necessarily completely now, as I indicated earlier this morning, in your papers, possibly, how would you accommodate or observe, how would you observe the proscription of the Commission in its notice that there was to be no cross-examination in this proceeding, other than questioning by the members of the Board?

MR. FREEMAN: I think under those circumstances —

CHAIRMAN PAGLIN: Would you seek a modification?

MR. FREEMAN: I certainly do. I think under those circumstances, confronted with a specific question in a specific context, if the Board called certain witnesses and it felt that under its own questioning, the legitimate concerns of some of the participants as to the adequacy of the record had not been met, then I think it would be appropriate for this Board, under those extraordinary circumstances to seek further advice and guidance from the Commission and to make its recommendations to the Commission.

I think it would be necessary to have a supplemental order from the Commission in that event, sir.

CHAIRMAN PAGLIN: Again, because the order as it stands now, besides saying no cross-examination, also indicates that the certification of the transcript, so to speak, to the Commission will be without a recommendation or a decision [478] as such from the Board, but with an indentification of issues.

MR. FREEMAN: I think Mr. Gleason very well pointed out that Mr. Roisman wants the formal right of discovery, but there is no indication that he has asked anybody for anything, and it has been denied to him.

In fact, I think the whole Staff position in this proceeding has been to make everything available to everybody. I think before Mr. Roisman can complain that he has been denied the right of discovery, I think he ought to say what he wants that he has not been able to get.

Similarly as to the right to cross-examination, the only way I can see that right arising would be if there were some documents before the Board by some author and there was some question concerning its authenticity or whether he still held those views, again the Board itself might, in such a situation, obtain a written communication from him that would clear up the doubt.

It is very rare — I really just can't see abstractly — I can't hypothesize the fact situation where the right to oral cross-examination would be necessary. I imagine that there could be some circumstances where it might be necessary, but I think we would have to look at those matters in terms of concrete situations and absent an exhaustion of the remedies which are afforded to all participants in this proceeding, and the encountering of such a situation [479]
by pursuing those procedures, I don't see how anyone is

prejudiced or could be prejudiced by the way the Commission is proceeding in this matter.

CHAIRMAN PAGLIN: Finally, Mr. Freeman, you indicated that in your further wirtten submission, you will point to the issues, at least as you see them, that require further consideration.

MR. FREEMAN: Yes, sir. And that brings me to one point I meant to mention and haven't, and that is that yesterday Mr. Roisman indicated that he was preparing a very massive submission.

Under the procedures we now have, that would come at the end of the proceedings, and in effect none of us would have any opportunity to further comment on that.

CHAIRMAN PAGLIN: I anticipated that, Mr. Freeman, and I would prefer to handle that matter as a procedural thing at the conclusion of the other testimony. I would seek the views of the participants at that time.

MR. FREEMAN: I do think some method should be allowed here so that before the record is finally closed, if any of the participants feel there are still substantial questions answered on the record, they should be permitted or indeed required to bring those questions to the attention of the Board so that the Board may take one final look to see whether or not any supplemental proceedings are in
[480]
order, in order to complete the record for the Commission.

CHAIRMAN PAGLIN: As I say, we will deal with that matter at the conclusion of all of the oral testimony, because it is a procedural matter that I agree requires some resolution.

Does that complete your presentation?

MR. FREEMAN: Yes, sir.

CHAIRMAN PAGLIN: We thank you.

We think this is an appropriate time at which to call the recess for lunch. It is now five minutes to 1:00. We will recess until 2:00 o'clock, at which time we will hear the rest of the participants and such other procedures that are required.

(Whereupon, at 12:55 p.m., the hearing was recessed, to reconvene at 2:00 p.m., this same day.)

UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

IN THE MATTER OF	
RULE MAKING HEARING ENVIRONMENTAL EFFECTS OF THE URANIUM FUEL CYCLE	Dkt. No. RM-50-3

SUPPLEMENTAL WRITTEN STATEMENT OF GENERAL ELECTRIC COMPANY

General Electric Company has reviewed the filings of the various individuals and groups in the above-referenced proceeding and the testimony of the participants at the hearing conducted February 1 and 2, 1973 and is filing this supplemental written statement pursuant to the Commission's Notice of Hearing, dated December 27, 1972.

Upon review of the written filings and testimony at the hearing, General Electric has concluded that the contents of its written statement, dated January 26, 1973, previously filed in this proceeding are still valid and applicable to this proceeding. In addition, we believe that several of the comments contained in that written statement with regard to the Staff's approach are extremely appropriate with regard to the testimony received at the hearing.

We would like to emphasize our strong support for the generic treatment of the environmental effects of the nuclear fuel cycle and our belief that either of the alternatives proposed by the Commission would be adequate to fulfill the requirements of NEPA. We continue to favor the third alternative proposed by the utility group represented by Mr. George Freeman, Jr. with appropriate attention given to our suggested improvements.

In regard to the environmental survey document itself, and the supporting technical arguments which were made in the proceeding, we would like to reiterate our positions on the following points:

1. In assessing environmental costs for cost-benefit balancing, it is essential in surveys of this type, that the Commission rely on realistic estimates of impacts as opposed to conservative estimates such as are sometimes used in assessing the safety of various systems.

2. We believe that the Commission should adopt a consistent posture in regard to evaluation of environmental effects and that these environmental effects should be evaluated at the point of actual impact in the environment using recognized factors for occupancy, shielding from structures, and dilution effects prior to the emissions coming in contact with the actual recipients. It is particularly disturbing to see assessments of environmental impact and concentrations made at the point of discharge of gaseous and liquid effluents for the sake of convenience without considering what the actual impact of these releases will be on the affected parties.

3. We believe that a basis for comparison such as natural background concentrations and radiation levels should be stated to provide a reference point from which valid cost-benefit balancing can be initiated.

In addition to the foregoing comments, we offer the following comments on specific portions of the testimony:

STAFF TESTIMONY

In the discussion of waste disposal practices (pp 85-86), the Staff estimates the releases of radioactive materials in the liquid effluents for the model plants and states that waste such as cladding hulls are buried on site. While this

has been accepted practice in some plants, we believe that the report should indicate that future plants may not utilize these waste management practices and that therefore environmental effects from such plants will be further reduced below those ascribed to the model plant. For example, the Midwest Fuel Recovery Plant does not discharge any radioactive materials of process origin in its liquid effluent streams, and the cladding hulls are not buried on site but are retained within a stainless steel lined reinforced concrete structure at a below-grade elevation.

Mr. Smiley referred to achievement of the "as low as practicable" objectives, using the best possible technology (p 147). We believe that in many instances the use of the best possible technology is neither practicable nor justified as there are many things which are possible but yet would have no measurable effect in reducing impacts. While we agree with the maintaining of radiation exposures to plant personnel and the general public as low as practicable, we do not believe that requiring use of "best possible technology" to be a necessary corollary for achieving that objective.

In regard to Dr. Pittman's testimony, we are concerned about conservative assumptions which have been utilized in evaluating the impact of alternate waste storage facilities. The use of such conservatisms, while they overstate the end effects, may be such as to raise a question of credibility regarding the actual analyses. In regard to the accident analysis, the assumption was made that if a waste can were dropped, 100% of the contained contents would become airborne in finely divided particles such that they would be swept from the room and into the ventilation system (p 105). We believe that such assumption regarding this source term is conservative by several orders of magnitude

and, in fact, beyond the realm of physical possibility. Additionally, Dr. Pittman states categorically that if the cooling system failed, the stored containers would melt (p 101, 103-105). Based on the data given in his testimony, it appears to us very unlikely that containers of the size described containing only 5 kW of heat could melt down. Further discussion of this in the Survey would be appropriate. In summary, we feel that at every stage of the report the best technical assumptions should be made and the best models used to provide realistic estimates of what the actual releases will be and what their impact in the environs will be.

EPA TESTIMONY

While a review of fuel cycles other than the nuclear fuel cycle is not appropriate for this proceeding, we do support Mr. Rowe's request that an environmental survey of other fuel cycles be undertaken. We believe that such an environmental survey would demonstrate that the environmental impact of the nuclear fuel cycle is not only small in absolute terms, but also in relative terms.

STEVE J. GADLER TESTIMONY

This testimony seems to be wholly without merit as it lacks any scientific or technical basis to support the allegations which have been raised. There does not appear to be understanding of even the most fundamental of engineering principles. An example of this was Mr. Gadler's attempt to apply an air-filtration efficiency of 99.9%, which is applicable only to the effluent air stream to the input or feed to a reprocessing plant in order to estimate the alpha emissions from such a plant (p 174). We find that Mr. Gadler's testimony does not cast any clouds on the credibility of the Staff's environmental survey report.

TESTIMONY OF DR. E. P. RADFORD

We believe that it is significant to note Dr. Radford's statements in regard to the timeliness of nuclear fission power in meeting the nation's energy needs and also his statements regarding his opinion that the Staff's as low as practicable Appendix I guidelines are too low and represent an overreaction by the Staff. We believe that evaluation of Dr. Radford's comments within the context of these two statements will indicate that his concerns are principally those of a scientific nature regarding the desirability of further study as to the effects of low-level radiation exposure and as to the movement of these radioactive materials in the environs. We do not believe that Dr. Radford's comments, therefore, amount to an attack on the nuclear power program or a request of further delays in the licensing of nuclear facilities, but rather, as an effort to obtain support for further scientific studies in the area of low-level radiation effects. Dr. Radford did raise four specific points principally in regard to the Midwest Fuel Recovery Plant on which we would like to comment:

1. *Meterological Diffusion Estimates (pp 240-241)*

We believe that the factor of 3 difference between the estimates of the Department of Commerce and those of General Electric can be attributed principally to the simplifying assumptions which were used by the Department of Commerce and to their lack of actual meterological data in making their estimates. Their estimates were based on generalized diffusion parameters and averaged meterological conditions, whereas the estimates performed by General Electric and substantiated essentially by the Staff were based on actual site characteristics and actual measurements of site meterology over an extended period of time.

2. *Remote Maintenance Techniques (p 246)*

Dr. Radford expressed concern over the ability of the company to maintain the plant in its as-constructed condition because of the fact that once the irradiated materials have been introduced into the canyon, actual human entry into the canyon will no longer by possible. The equipment at the MFRP is designed such that it can be removed using the overhead canyon crane and viewing equipment without requiring human entry into the canyon. This is based on plant maintenance practices which have been successfully used in Commission facilities for almost 30 years. Thus, if a piece of equipment in the canyon should fail to function properly, it would be removed and decontaminated and a new or repaired piece of equipment would be reinstalled in its place, all without requiring human access into the canyon-processing area. Thus, the plant is designed to be maintained in its original operating condition throughout its operating life.

3. *Detection of Upsets (p 259)*

Dr. Radford also expressed concern that there could be undetected higher-than-normal releases of radioactivity into the MFRP confinement systems. In this regard, it should be noted that this is basically a chemical process and that there are extensive process monitors throughout the plant with remote readouts and alarms in a central control room. Further, the sumps in the process cells are equipped with liquid-level detectors and alarms such that any spillage from vessels would be detected and alarmed. Also, the off-gas systems all have radiation monitors and alarms such that any higher-than-normal releases into the process or ventilation off-gas systems would be promptly detected

and identified. Thus, there would be instantaneous detection of any substantial process upset or release of higher-than-normal amounts of radioactivity into the process off-gas system, thereby assuring prompt detection and initiation of protective measures.

4. *Accumulation of Radioactive Materials in the Plant (p 259)*

In regard to Dr. Radford's concern in this area, it should be pointed out that there are provisions for detecting leakage from the vessels and for returning such leakage to the process system for disposal as a normal process waste. Because of these provisions for clean-out of the cells, the maximum accumulation at any time in the plant would be only a very small fraction of the in-process inventory at that time. Therefore, the effects on radiation dose rates in the personnel-occupied zones of the building would be immeasurable and of no significance.

TESTIMONY OF DR. HENRY W. KENDALL

Most of Dr. Kendall's testimony was not within the scope of this proceeding, and we have not undertaken to prolong the record with detailed analysis of these aspects of it. However, we would like to point out to the Board that Dr. Kendall extracted one number from Wash-1250 (p 268) without referencing the six pages of discussion putting that number in appropriate context. He proceeded to equate General Electric's accident probability projections to that number (p 269). General Electric's most recent probability projections are contained in its comments on the AEC's Draft Environmental Statement in the ECCS Rule Making Proceeding (Docket No. RM-50-1). These comments estimate a pipe rupture probability ranging from 1 in 10,000

to 1 in 100,000, certainly significantly different from the 1 in 1,000 to which Dr. Kendall sought to compare it. Neither of the documents referenced by Dr. Kendall support the extrapolations which he attempted to make from them.

Dr. Kendall expressed concern regarding the capability for interim storage of high-level radioactive wastes at or near the earth's surface in engineered storage facilities. We believe that the satisfactory containment of such materials for the necessary periods of time is well within the scope of presently available technology. In this regard, it should be pointed out that the radiation dose rates associated with the penetrating gamma radiation and the heat dissipation which make the waste difficult to contain will be greatly reduced within a few decades. After a storage period of several years, waste should require no cooling and substantially reduced radiation shielding. Thus, at that time the problem becomes principally one of containment of the dry material which substantially reduces the requirements that would be placed on such storage containers.

We trust that the foregoing comments will be of assistance to the Commission in its review and deliberations in this rule making proceeding. The opportunity to participate is appreciated.

Respectfully submitted,

GENERAL ELECTRIC COMPANY
C. W. SMITH, *Manager*
Licensing & Transportation

ATT. A

NUCLEAR FUEL CYCLE PROCEEDING — 50-3

Max D. Paglin, Esq., Chairman
Hearing Board — ASLB
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dr. Martin J. Steindler
411 Sandburg Street
Park Forest, Illinois 60466

Dr. John C. Geyer, Chairman
Dept. of Geography and
Environmental Engineering
The Johns Hopkins University
513 Ames Hall
Baltimore, Md. 21218

Mr. C. Wesley Smith, Manager
Licensing and Transportation
Nuclear Fuel Department
General Electric Company
175 Curtner Avenue
San Jose, California 95114

Mr. John M. Arthur
Chairman of the Board and
Chief Executive Officer
Duquesne Light Company
435 Sixth Avenue
Pittsburgh, Pa. 15219

Mr. Donald C. Lutken, President
Mississippi Power &
Light Company
P.O. Box 1640
Jackson, Mississippi 39205

Mr. John W. Landis, President
Gulf General Atomic Company
P.O. Box 608
San Diego, California 92112

Mr. W.D. Rowe
Acting Assistant Administrator
for Categorical Programs
U.S. Environmental Protection
Agency
Washington, D.C. 20460

Professor Lawrence Ruby
College of Engineering
Department of Nuclear
Engineering
University of California,
Berkeley
Berkeley, California 94720

Mr. H.W. Brook, General
Counsel and Secretary
Nuclear Fuel Services, Inc.
6000 Executive Boulevard
Rockville, Maryland 20852

Mr. Ken Dzugan,
Research Scientist
Minnesota Pollution Control
Agency
717 Delaware Street, S.E.
Minneapolis, Minnesota 55440

Mr. John D. Hoffman
Sierra Club Legal Defense
Fund, Inc.
311 California Street
San Francisco, California 94104

Mr. Steven J. Gadler
2120 Carter Avenue
St. Paul, Minnesota 55108

Mr. Jack C. Fensterstock
Teknekron, Inc.
1619 Massachusetts Ave., N.W.
Washington, D.C. 20036

Mr. Edwin A. Wiggin, Secretary
Forum Committee on Nuclear
Fuel Cycle Services
Atomic Industrial Forum, Inc.
475 Park Avenue South
New York, New York 10016

George L. Edgar, Esq.
Morgan, Lewis and Beckius
1140 Connecticut Ave., N.W.
Suite 1100
Washington, D.C. 20036

Mr. Richard H. Stroud
Executive Vice President
Sport Fishing Institute
608 Thirteenth St., N.W.
Washington, D.C. 20005

Anthony Z. Roisman, Esq.
Berlin, Roisman and Kessler
1712 N Street, N.W.
Washington, D.C. 20036

James P. Murray, Jr., Esq.
Regulatory Staff Counsel
U.S. Atomic Energy Commission
Washington, D.C. 20545

Myron M. Cherry
Jenner and Block
One IBM Plaza
Chicago, Illinois 60611

Mr. W.J. Dollard,
General Manager
Nuclear Fuel Division
Westinghouse Electric
Corporation
Box 366
Pittsburgh, Pa. 15230

Mr. R.L. Dickeman, President
Jersey Nuclear Company, Inc.
(Exxon Nuclear Company, Inc.)
777 106th Ave., N.E.
Bellevue, Washington 98004

Dr. Leonard Geller
Vice President-Research
The S.M. Stoller Corporation
1250 Broadway
New York, New York 10001

J. Bruce MacDonald, Esq.
New York State
Dept. of Commerce
New York State
Atomic Energy Council
112 State Street
Albany, New York 12207

Mr. Samuel R. Madison
New York State
Atomic Energy Council
New York State
Public Service Commission
44 Holland Avenue
Albany, New York 12208

Mr. Terry R. Lash
Natural Resources Defense
Council
36 West 44th Street
New York, New York 10036

Mr. Arnold R. Fritsch
Gulf United Nuclear
Fuels Corp.
Grasslands Roads
Elmsford, New York 10523

Mr. Franklin L. Gage
27 Hastings Avenue
Croton-on-Hudson,
New York 10520

Miss Mary E. Cahoon
Box 1333
Ark. Tech.
Russelville, Arkansas 72801

J. Allen Overton, Jr., President
American Mining Congress
1100 Ring Building
Washington, D.C. 20036

Mr. W.H. Owen, Vice President
Duke Power Company
Box 2178 Power Building
Charlotte, North Carolina 28201

Mr. Richard E. Raymond,
Senior Vice President
System Engineering Operation
Florida Power Corporation
P.O. Box 14042
St. Petersburg, Florida 33733

Mr. Samuel Edlow, President
Edlow International
Suite 404-5
1100 17th St., N.W.
Washington, D.C. 20036

Mr. H.P. Lyle, Vice President
Electric Producing and
Engineering
No. Indiana Public Service Co.
5265 Holman Avenue
Hammond, Indiana 42365

George C. Freeman, Jr., Esq.
Hunton, Williams, Gay & Gibson
700 East Main Street
P.O. Box 1535
Richmond, Virginia 23212

Mr. Frank Karas
Chief, Public Proceedings Staff
Office of the Secretary of
the Commission
U.S. Atomic Energy Commission
Washington, D.C. 20545
(10 copies)

Arvin Upton, Esq.
c/o James P. McGranery, Jr.
LeBoef, Lamb, Leiby & MacRae
1821 Jefferson Pl., N.W.
Washington, D.C. 20036

CONSOLIDATED NATIONAL INTERVENORS
UNION OF CONCERNED SCIENTISTS
STATEMENT WITH RESPECT
TO LEGAL CONSIDERATIONS
OF THE PROPOSED REGULATIONS
ON THE NUCLEAR FUEL CYCLE

Prepared by:

BERLIN, ROISMAN & KESSLER
ANTHONY Z. ROISMAN
1712 N Street, N. W.
Washington, D. C. 20036

JIM LIEBERMAN
Law Student Assistant

I **INTRODUCTION**

Under Section 2 of the Atomic Energy Act of 1954, as amended, a purpose of the Act is to provide regulation to protect the health and safety of the public. The public health and safety under the Act § 3, serves as the limiting factor in the development and utilization of atomic energy for peaceful purposes. The Commission has authority to revoke or to refuse a license under §§ 103 and 186 of the Act for a facility which does not meet the health and safety standards of 10 CFR 50.40(c). Therefore, it is our position that if the Commission finds as the result of the hearings on the Fuel Cycle Survey that utilization of nuclear energy is inherently inimical to the health and safety of the public, because of the existence of health and safety hazards for which there are no presently available acceptable solutions then it is obligated and has the present statutory authority to call a moratorium on further construction and operation of nuclear power plants.

Appendix D of 10 CFR Part 50 essentially follows NEPA which requires, *inter alia*, a discussion of the environmental impact of proposed actions that may effect the environment. The discussion of the environmental impact is required to insure that the goal of NEPA — to prevent initiation of government action which will do irreparable damage to the air, land and water which supports life on earth — is met.[1]

It should be further noted that the procedures of Section 102 of NEPA is not intended just "to file detailed impact studies which will fill government archives but to give effect to the goals of Section 101 of NEPA." *EDF* v. *Corps of Engineers*, 4 ERC 1721, 1726 (8th Cir., November 28, 1972).

There is no doubt that the fuel cycle represents a relevant part of the environmental effect of a nuclear power plant

[1] 115 Cong. Rec. 40416 (1[illegible]) (Remarks of Senator Jackson).

and that a detailed statement, does not comply with the requirements of applicable law if it does not consider the issues of mining, milling, manufacturing fuel and transportation, reprocessing and disposal of high level wastes. See Natural Resources Defense Council's brief on this issue before the ASLAB, In the Matter of Vermont Yankee, Docket No. 50-271.

The required environmental discussion is not limited to just the factors relating to the effect of the proposed action on the air, water, and land but also to the factors that may effect the quality of human environment. *Hanly* v. *Mitchell*, 4 ERC 1157 (2nd Cir. 1972) If in *Hanly, supra,* the court required the consideration of environmental factors such as noise, traffic, mass transportation, crime, congestion, and drugs in the statement for a jail, the potential security problems in the transportation of nuclear material is an aspect of the fuel cycle that should certainly be considered in the fuel cycle's statement.

The only legitimate question should be how to develop procedures for disclosure of this impact which are both fair and avoid unnecessary delay.

In the past the Commission has limited consideration of environmental matters relating to the fuel cycle to environmental effects of the

> "Transportation of fuel elements from the fuel fabrication plant to the reactor as well as the transportation of spent fuel elements from the reactor to the fuel reprocessing plant and the transportation of packaged radioactive material from the reactor to low level burial grounds." "Guide to Preparing Environmental Reports by Director of Regulation" Sept. 9, 1971.[2]

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[2] Under the regulations then in effect, this Guide does not constitute a valid regulation of the Commission and is merely a statement of position of the Director of Regulation.

The Commission ASLAB agreed with this limited interpretation of the required scope of an environmental impact statement. In its decision of *In the Matter of Vermont Yankee Nuclear Power Corp. (Vermont Yankee Nuclear Power Station)*, Docket No. 50-271, Memorandum and Order, June 6, 1972 (ALAB-56), and Decision, October 11, 1972 (ALAB-73), the Appeal Board held that mining and manufacturing of reactor and reprocessing and disposal of nuclear wastes are not within the scope of the environmental review prescribed by NEPA and AEC's regulations.

However, in *Calvert Cliff's Coordinating Committee* v. *AEC*, 449 F 2d 1109, 1112 (D.C. Cir. 1971) The Court said that the Commission is required by NEPA to consider environmental issues just as it considers other matters within their mandate". Therefore, AEC, by not considering the full environmental effect of the fuel cycle, has been following a policy contrary to NEPA and also has disregarded NEPA's legislative history that "[N]o agency will [now] be able to maintain that it has . . . no requirement to consider the environmental consequences of its actions."[3]

In 1971, the court in *Calvert Cliffs, supra,* at 1119, expressed shock with the delay the Commission took in carrying out NEPA's requirements. Now a year and a half later, over three years after NEPA's effective date, the Commission is still proceeding at a "funeral procession pace" and has yet to fulfill its legal obligations to consider the full environmental effects of the fuel cycle to the "fullest extent possible" in its review process.

II PROPOSED ALTERNATIVES

The AEC has now questioned their position of excluding environmental effects associated with the fuel cycle. Two

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[3] Senator Jackson, *supra,* Note 1.

alternative regulations, which take into account the environmental effects associated with the uranium fuel cycle, are being considered. Both alternatives are based on the information provided in the Regulatory Staff's report entitled, "Environmental Survey of the Nuclear Fuel Cycle," November 6, 1972.

A) ALTERNATIVE I

Alternative I is basically the current policy which disregards the intent of NEPA by not considering the full fuel cycle's impact on the environment. Admitting there is an impact, Alternative I concludes, on the basis of this single survey, that, "when factored into the cost benefit analysis, [the environmental effects of the fuel cycle] are sufficiently small as not to affect significantly the resultant conclusion". However, once admitting there is an impact, it is not possible merely to dismiss it if it is related to a major federal action. Section 102 c (ii) of NEPA does not state that impact statements consider only large adverse environmental effects but rather it states "any adverse environmental effect" be considered.

In fact, Judge Wright in *Scrap* v. *U.S.*, 346 FS187 (Three Judge Court) (D.D.C. 1972) and Chief Judge Friendly in *Hawly, infra,* agree that "a statement is required whenever the actions *arguably* will have an adverse environmental impact."

Alternative I is based upon the assumption that the environmental cost due to an individual plant's fuel cycle does not significantly affect the environment. However, AEC raises two questions as to the certainty of that conclusion. The first is that, "[T]here does not appear to be any way to ascertain with any degree of certainty which of the uranium mines or mills, uranium hexafluoride plants, isotopic

enrichment facilities, and fuel fabrication plants in existence or to be operated in the future will contribute fuel to a given nuclear power reactor, or which of the various fuel reprocessing plants or commercial burial grounds now in existence or to be constructed from time to time will receive irradiated fuel or wastes from any given nuclear power reactor," and

> [M]any of the various elements in the nuclear fuel cycle involve varying methods or processes with different environmental effects and there is no reason to believe that during the useful life of any given nuclear power reactor other methods or processes with different effects will not be developed.

37 F.R. 24192 (November 15, 1972)

Further at some point in time a new mill, mine, reprocessing plant or fabricating plant, etc. will be needed to expand the existing capacity because of the demand of a single additional nuclear plant. That event will certainly produce a significant incremental cost.

A similar analysis was made in *Hanly* v. *Kleindienst*, 4ERC 1785 (2nd Cir. December 5, 1972) where the Court said that the one additional factory "may represent the straw that breaks the back of the environmental camel." Therefore, NEPA requires, in cases where incremental environmental costs can lead to a significant environmental cost, that the absolute, as well as comparative effects of a major federal action must be considered." *Hanly, supra.*

Regardless of the lack of factual support for alternative I (a point which will be emphasised by our technical submittal) This alternative is also legally unjustifiable as the National Resources Defense Counsel brief in Vermont Yankee clearly demonstrates.

B) **ALTERNATIVE II**

Alternative II includes the transportation effects currently considered as well as the environmental costs of the fuel cycle (other than transportation of cold fuel to, and irradiated fuel from, the reactor.) However, the consideration of the environmental cost of the fuel cycle is limited to Table S-3 of the Survey. The AEC in its announcement of this rule making hearing 37 FR 2 4192 (November 15, 1972) described the survey not as *the* basis but as "*a* basis for an inforned consideration of the generic question of the environmental impact associated with the uranium fuel cycle in light water cooled nuclear power reactor licensing proceedings." The implication here is that there are other bases that may be used to form a different conclusion as to the information that should be supplied in Table S-3. The use of this Table S-3 to the exclusion of all other information does not meet the spirit or letter of NEPA § 102c because it does not provide sufficient information for the decision making process. *NRDC* v. *Morton*, 458 F2d 827, 833 (D.C. Cir. 1972)

Under Alternative II, Table S-3 is incorporated into the environmental impact statement of the individual plant. Appendix D of 10 CFR Part 50 and NEPA § 102c requires a discussion of alternatives. The discussion of alternatives that is required in the impact statement includes the alternative of not proceeding with the proposed action *NRDC* v. *Morton, supra,* at 833. However, the discussion of alternatives of the fuel cycle as a necessary part of the plant, requires a discussion of the alternatives methods for the operational steps of the fuel cycle not merely the alternative of no wastes being produced or less waste being produced. The alternative of not producing nuclear fuel and wastes belongs in the discussion of the alternatives of not building the power plant which must be part of the NEPA review

of the individual nuclear power plant and not the impact statement of the fuel cycle. The Survey does not meet this requirement of a discussion of alternative modes of operations for the fuel cycle. In fact, at S-2 it notes that future documents will consider alternative fuel cycles.

Therefore because of the lack of a discussion of alternative fuel cycles and the possibility of exclusion of responsible information, the publication of the data in Table S-3 does not meet the requirements of an Environmental Impact Statement. This view is strongly supported by the Survey itself at FW-1 where the survey states that, "[i]t, [the survey] is not a detailed environmental statement as defined in the National Environmental Policy Act of 1969 and Appendix D of 10 CFR 50 of the AEC's regulations."

If the data in S-3 is to be incorporated into the environmental impact of each plant, then it follows it should be treated as any other information included in an impact statement. Therefore, it will be circulated to the various Federal and State agencies, it will be subject to discovery by the parties, and the preparers of the survey will be subject to cross examination.

The language in alternative 2 that the environmental effect of the fuel cycle, "shall be as set forth in Table S-3" may mean that the data used in the fuel cycle will not be subject to intensive questioning such as to the validity of assumptions and to the analysis used which the remainder of the information in the environmental impact statement in normally subjected. Technical analysis without complete airing of the assumptions are often misleading and not useful. If that interpretation is followed the phrase of 102C, "shall accompany the proposal through the existing agency review process," would be meaningless. *Calvert Cliffs, supra* at 1117.

While Alternative II expands the current consideration of the fuel cycle, it has the weakness of not providing for the updating of the environmental analysis of the fuel cycle (see third alternative.) It also requires duplicate discovery and cross examination in each power plant hearing in order to fulfil the requirements of NEPA. What is necessary is a serious examination of the fuel cycle using the data similar to that in Table S-3, supplementing it with additional information, as necessary, and updating the survey, as new information is obtained.

ALTERNATIVE III

A) Generic Hearing

In view of the expressed uncertainties and the weakness of Alternative I and II a complete examination of the fuel cycle could best be done by an on going generic hearing.

This third alternative would be as follows:

In the case of Light Water Cooled Nuclear Power Reactors, the applicant's environmental report and the Commission's detailed statement shall contain a full discussion of, inter alia, the environmental effects of the transportation of cold fuel to the reactor and irradiated fuel from the reactor to a fuel reprocessing plant and the transportation of low level wastes and high level solid wastes (other than irradiated fuel) from the reactor to depositories. In such documents, the contribution of the environmental effects of uranium mining and milling, the production of uranium hexofluoride, isotopic enrichment, fuel fabrication, reprocessing of irradiated fuel, transportation and disposal of wastes resulting from such reprocessing, disposal of low level and high level solid wastes and transportation related to such activities (other than transportation of cold fuel to, and irradiated fuel from the reactor), to the environmental costs of licensing the nuclear power reactor shall be based on the environmental impact statement prepared for, and the findings resulting from an ongoing generic fuel cycle adjudicatory

hearing. To the extent that findings are reached different from the detailed statement, the statement will be deemed modified to agree with the findings. This generic hearing shall periodically convene to issue additional or modified findings as the generic fuel cycle's environmental impact statement is updated.

Parties to the individual licensing hearings would simultaneously become parties to the generic hearing. Therefore, objection to the treatment of the fuel cycles' environmental issue should be raised at the generic hearing. However the right to challenge the full cycle issue at the individual licensing hearing will be permitted under 1) a showing of good cause as why it was not possible to raise the issue at the generic hearing, 2) a showing that the issue is material and of substantial nature, and 3) that there has not been delay in raising the issue by the party raising it.

NEPA does not in itself require an adjudicatory hearing. It only requires that environmental issues be considered at every step of the existing review process and under the Commission's regulations the existing hearing proceedares for licensing one adjudicatory. Therefore, the environmental review to be part of the existing agency review process must also be adjudicatory. Thus, this generic hearing would also be adjudicatory in nature in accordance with Subpart G of 10 CFR Part 2, because it replaced the portion of the adjudicatory environmental review required by NEPA at each nuclear plant licensing proceeding. It would provide assurance that all environmental matters relating to the fuel cycle will be considered at one hearing. Such a hearing would provide an opportunity for all interested parties to raise valid questions as to the environmental effects of the fuel cycle.

The generic hearing may produce some of the administrative problems which occurred in ECCS. Again it should be noted that the full consideration of the environmental questions pertaining to the fuel cycle is mandated by NEPA. It

is not a flexible requirement such that mere administrative difficulty, delay, or economic cost can prevent enforcement of NEPA's provisions. *Calvert Cliffs, supra* at 1115. However, this does not preclude the Commission from taking timely steps for an orderly process which is both fair and prompt.

One step the Commission could take is to order a complete and adequate discovery prior to the hearing. Such a discovery order should include such things as a list of all documents used or relied upon in the preparation of the survey and the Commission's position. The time period for discovery should include sufficient time for the parties to obtain the above mentioned documents and examine them, as necessary, in order to facilitate interrogatories and establish the issues. This form of discovery process would prevent needless delays during the actual hearing as well as provide the opportunity for a meaningful contribution by the parties to the decision making process.

The regulatory staff would gather information itself as well as receive information from others. It would also have the responsibility of issuing a draft environmental impact statement of the fuel cycle. This statement would include all impacts of the AEC's failure to face up to this issue at an early date. If the immediate post *Calvert Cliffs* response on the fuel cycle had been what is currently proposed (over a year later), the period of delay associated with implementation of that decision could have accomadated the time needed to obtain initial findings on the fuel cycle. The AEC's decision to deal with the fuel cycle following resolution of other environmental problems rather than at the same time was ill-conceived. Having chosen that course it has no choice but to accept the consequences. All findings and statements issued by the generic ASLB up to the time of decision on an individual licensing proceeding should be

available for consideration by the Board of that licensing proceeding.

No doubt there will arise cases when a gap will arise between the time new information is submitted on the fuel cycle question and the further generic review process is completed by submitting the findings to the individual boards. Courts have given discretion to agencies in excluding evidence that updates *earlier* administrative proceedings. *U.S.* v. *ICC*, 396 U.S. 491 (1970). But an administrative proceeding where relevant evidence is excluded is open to an attack as a violation of due process if the rules for updating are not fair and reasonable *Marine Transport Line, Inc.*, v. *U.S.* 1973 F.Supp. 326, 329 (D.C. 1959).

A problem may arise when a party to a current licensing proceeding was not a party to the generic hearing and objects to the fuel cycle's findings.

In this case the Commission must use its discretion and balance the due process right with the substance of the objection, remembering there is a difference bwtween repetitious evidence and new evidence. The AEC has an affirmative duty to see that the record is complete and to consider all relevant facts. *Senic Hudson Preservation Conf.* v. *FPC*, 359 F.2d 608, 620 (2nd Cir. 1965).

Questions as to the reopening of or challenges to the generic hearing could be treated in similar fashion as modification of the Commission's regulations is presently done under 10 CFR 2.758. The Commission could establish fair and reasonable standards for challenge to or reopening of the fuel cycle hearings such as 1) a showing of good cause as why it was not possible to raise the issue at the generic hearing, 2) a showing that the issue is material and of substantial nature, and 3) that there has not been delay in raising the issue by the party raising it.

In conclusion there will be difficult procedural problems associated with making the generic hearing workable, but they are not insurmountable, hopefully they will be solved as the periodic hearing continues. In view of the Commission's delays in carrying out the required review of the environmental effects of the fuel cycle a few small delays in working out a proper procedure for the generic hearing system is not unjustified.

On the other hand the generic hearing will meet the mandatory requirement of NEPA to fully consider the complete environmental impact of the individual nuclear power plant. It will meet the "essence and thrust of NEPA that the pertinent statement serve to gather in one place a discussion of the relative environmental impact alternatives." *NRDC* v. *Morton, supra,* at 834. The concept of the generic hearing will permit consolidation of the fuel cycle questions and thus save NEPA resources that would otherwise be spent at the required individual licensing hearings. Periodically updating the effects of the fuel cycle will provide the required systematic interdisciplimary approach needed to solve the weaknesses of both Alternatives I and II which rely on a single survey that may quickly become obsolete.

B) Treatment of Environmental Impact of Known Steps In the Fuel Cycle

In some steps of the fuel cycle, different plants utilize a variety of alternative processes and operations, some of which have substantially different environmental impacts. A proper evaluation should include the environmental effect of each alternative process or operation within each step in the fuel cycle. As an example, the normalized or weighted environmental impact of the mining step should be given as in Table S-3A. Then that information should be broken down into the environmental effects of a typical open pit

mine, the environmental effect of a typical underground mine, etc. In the case of the hexafluoride production facility, the normalized or weighted environmental data would be submitted as in Table S-3A. That information would then be broken down into the environmental effects associated with a typical facility using the hydrofluoride method and a typical facility using the wet solvent extraction method, etc.

In the case where a particular process for a step in the fuel cycle has been finalized (i.e. a decision has been made to fuel the plant with uranium mined from an underground mine rather than from an open pit mine), the licensing board of the individual nuclear power plant will be able to assign from the generic fuel cycle's impact statement and findings, the incremental environmental cost associated with that process (i.e. the cost associated with a typical underground uranium mine).

Where the particular process for a step in the fuel cycle has not been finalized or the process is reasonably subject to change during the life of the nuclear plant (i.e. the uranium may be mined fron either an underground mine, or open pit mine, or both) the licensing board of the individual nuclear power plant will be able to find in the generic fuel cycle's impact statement and findings the normalized or weighted impact for the step along with the impact for each alternative process for that step (i.e. for the mining step, the board will find the normalized or weighted impact of the model mining operation as well as the impact of a typical open pit mining operations and the impact of the typical underground mining operation. The licensing board, after having access to these comparative environmental costs, is then in a position to assign a reasonable conservative value for the incremental costs associated with the step in question (i.e. the mining step in the above example).

C) Treatment of the Environmental Impact of Unknown Systems

One of the most shocking aspects of the Survey is the total paucity of data on the environmental impact of waste disposal The alleged bases for this is the unsubstantiated promise that whatever design is developed for waste disposal it will cope with all credible accidents. This approach is totally unacceptable. The purpose of an environmental analysis is to provide facts about potential environmental impact. Thus, what should be disclosed is the environmental impact of the currently developed waste disposal systems. Disclosure of the present state of the art regarding development of better systems can be included, but surely the hope that such systems will be developed cannot be used as an excuse to avoid discussing the known impacts of present methods. This is particularly relevant in as much as the AEC is determined to continue licensing plants to produce wastes even though there are no methods developed to dispose of the waste which meet the optimistic "no release" standard of the Survey.

Closely related to this waste disposal issue is the treatment of the environmental effects of accidents. There is no guarrel with the general proposition that under NEPA only so called credible accidents must be analyzed. But the statement must fully disclose the basis for justifying the relocation of the credible accidents. The criteria for determining what is credible must be disclosed and the basis for selecting that criteria must be given. Uncertanties in analysis must be compensated for by the use of conservative assumptions just as is now done for safety reviews.

D) Nature of the Generic (Consolidated) Hearing

1) *Adjudicatory Hearing*

Section 189 of the Act requires a hearing for persons affected by a proceeding. Under the Administrative Procedure Act, which is applicable to the Commission by §181 of the Act, a license is considered an order. The process for formulating an order under the APA §551(7) is adjudication. Therefore, the licensing process is adjudicatory.

This is in agreement with the testimony of former chairman Schlesinger and the general counsel, Martin Hoffman that the act requires adjudicatory licensing hearings. Hearings on Interim Nuclear Licensing before the Senate Interior and Insular Affairs Committee (HR. 13752) 92nd Congress, 2nd Session 50, 29 (1972). Roger Crampton, the former chairman of the Administrative Conference of the United States, has also noted that section 189(a) of the Act requires a trial type hearing. Licensing of Nuclear Facilities before the Joint Committee on Atomic Energy (HR 13731 and HR 13732) 92nd Cong., 2nd Session 454 (1972). In reference to the hearing process the Joint Committee on Atomic Energy has insisted that:

> The most meticulous attention be given to the scientific and technical problems associated with Atomic Energy Licensing and [The Committee] insists that there be full, free and public disclosure of these matters involving any particular reactor. Joint Committee on Atomic Energy, S. Rep. No. 92-707, 92nd Cong. 2nd Sess. 6 (1972).

There is some support for the view that the hearing requirement does not necessarily mean a trial type hearing and it is within the discretion of the Commission to decide the nature of the hearing. *Siegel* v. *U.S.*, 400 F.2d 778. (D.C. Cir. 1968). However, Siegel may be distinguished in that the issue there was outside the jurisdiction of the agency. But, even if the agency may have the discretion to

abandon the adjudicatory hearings, it has not yet acted to do so as 10 CFR Part 2 clearly indicates. Therefore, the current practice for reviewing safety questions at the Commission's Licensing Hearings is adjudicatory.

Section 102C of NEPA does not require a particular type of hearing. The statute only states that the environmental impact statement must accompany the "existing agency's review process." As seen from 10 CFR Part 50 App. D, the Commission has properly made the environmental review an adjudicatory process after it interpreted the existing agency's review process to be adjudicatory.

Once the Commission decides (as we contend it must) that the incremental cost of the fuel cycle must be factored into the decision making process, then it follows from NEPA that it must be subject to the same adjudicatory hearing process that the Commission uses with other technical, safety, and environmental issues. In reference to an adjudicatory environmental review, the court in *Greene County, supra* at 422 noted that:

> since the [environmental impact] statement may well go to waste unless it is subject to the full scrutiny of the hearing process, we [the Court] also believe that the intervenors must be given the opportunity to cross examine both PAGNY's and Commission's witnesses in light of the statement.

The Court in *Calvert Cliff's, supra*, also required the Commission to independently examine each statement on an individual basis to determine whether the staff's environmental review had been adequate.

Greene County, supra, *Calvert Cliff's, supra*, and the Commission's existing regulations stand for the proposition that review of the environmental effect of a nuclear project must be part of each and every licensing hearing. It follows that the environmental effects of the fuel cycle

must also be considered on a case by case basis. The Courts fully recognize that delay is incident to the mandate of NEPA. In *Greene County, supra* at 422 and *Calvert Cliff's, supra* at 1122 they said:

> Delay is a concomitant of the implemantation of the procedure prescribed by NEPA, and the spectre of a power crisis must not be used to create a blackout of environmental considerations in the agency review process.

Our proposal recognizes the delay that a repetitious consideration of the fuel cycle at every hearing would involve. Therefore the purpose of our generic hearing proposal is to replace each required adjudicatory hearing on the environmental effects of the fuel cycle in a single adjudicatory consolidated hearing.

The separation of the environmental questions into separate adjudicatory hearings was acceptable to the Court in *Greene County, supra.* There at footnote 23 the Court suggested one hearing "to gather information to aid the Commission in forming its statement" and then a second hearing, "to consider the merits of the licensing application." Our generic consolidation concept builds on the above suggestion by utilizing a single consolidated hearing to gather information and then feeding it into the local licensing hearings where the remaining environmental issues and all radiological issues will be fully explored and where alternatives will be considered and the final balance struck.

2) *Discovery*

We consider that the adjudicatory nature of AEC current licensing hearings has two essential ingredients, discovery and cross examination. We agree with the Commission's policy statement issued with its recent Part 2 revised regulations 37 FR 15127, August 28, 1972, (although not with all of the regulations or how they are being interpreted) that

proper discovery providing for production of documents, serving of interrogatories, and taking of depositions without the need of formal motions can expedite the hearing process.

There is no need for delays to result from the discovery process as occurred in ECCS when there was difficulty in obtaining discovery in the middle of the hearing. Procedural rules should be established before the hearing. Discovery should be completed before the hearing. Discovery should provide for availability of all documents that were used in the process of the preparation of the parties position. Because it is difficult to determine the position of the Staff in the Fuel Survey report, a bill of particulars expressely stating their positions should be required before discovery begins. Ideally there may be no reason for discovery against the staff as 10 CFR 2.790 (1972) contemplates the staff's position will be available thru public documents. However, this has not always occurred. Interrogatories should be used extensively to iron out issues and arrive at stipulations prior to hearing. Also pre hearing conferences should be used to prepare for an orderly hearing.

The key to an orderly hearing is to rationalize the role of the parties. There is no question that the Commission has used its vast resources on preparing its positions. At the same time there are also many capable scientists and engineers in industry and universities who have developed positions on the issues in question but who do not have vast resources at their disposal. Through discovery these scientist and engineers can get the necessary information to study the analyses, criteria and assumptions of the Commission's staff. They then can use their expertise to make a substantial contribution to the ultimate decision. The Council on Environmental Quality has noted "often indi-

viduals and groups can contribute data and insights beyond the expertise of the agency involved." *CEQ Report* 1 Env. L. Rep. 50059 (1971).

3) *Cross Examination*

It has been suggested that cross examination is not a practical method to get at the truth of technical matters. It is agreed that cross examination is not necessarily an efficient process. There are two concepts that must be weighed in establishing a hearing system, efficiency and accuracy. We are not dealing with such subjects as the labeling requirements for grocery products in our generic hearing but are dealing with the safety and environmental issues relating to a Nuclear Power System. Accuracy not efficiency must be the guideline. The Joint Committee, itself, has:

> insisted that the most meticulous attention be given to the scientific and technical problems associated with atomic energy licensing and has insisted that there be full, free and public discussion of these matters involving any particular reactor. JCAE-Senate Report 92,787, 92 Cong. 2nd Session 6 (May 19, 1972).

Cross examination serves to air views different from the final approved point of view and to explain why the final view is the approved view. No doubt without cross examination the Board may also ask these necessary questions. However, the adversary system tends to assure that the questioning will persever until the full answer requested is given. Dr. Steindler requested from the staff (TR 308) February 2, 1973, a comment on the quality of standards used by the Bureau of Mines in their assessment of both worker safety as well as evnironmental impact? After much explanation by the staff, Dr. Steindler accepted an answer that these are competent agencies and people working in this area but was not informed of the quality of work

done by these competent people. An attorney would be expected to continue asking questions until he received a definite answer.

Often pervasive cross examination is necessary to get at the basis for the position of the staff. The Board demonstrated a real need for cross examination at TR 139, February 1, 1973, where the Board noted that the Fuel Cycle Survey's underlying assumptions had not been documented. Thus the Board who must make the decision were at a loss of "how you got this" and "where you got that." The Staff commented that it did not realize that it had left our necessary references. Once again, in the absence of cross examination, the Board and members of the public did not learn of these assumptions nor were they aired in a public forum. Without these assumptions one could question how the Board can be expected to make their required evaluation of the staff's statement. It was probably for similar reasons that the Court in *Greene County, supra,* mandated cross examination when reviewing the environmental impact statements.

An alternative to cross examination may be a system where a number of experts sit down and arrive at a consensus. While under some circumstances this may be a practical system, it would not be manageable here Obviously experts like other men can reasonably differ. It has been suggested that:

> [T]he scientist seeks correct and accurate answers to problems by employing a high degree of precision in most instances, but precision does not guarantee accuracy because there are frequently intervening or overriding subjective judgements. To appreciate the difference between precision and accuracy, consider the case of the rifleman who shoots ten consecutive bull's eyes into the wrong target. Precise yes; accurate no.

Nickerson, *the Expert Technical Witness,* 50 A.B.A. Journal 731 (1969).

It is widely known that the Commission has two roles — promotion and regulation. The roles are not consistent and produce substantially different conclusions from the same facts. For instance note the divergence of views between Drs. Rosen and Colmar and Dr. Hannauer at the EEC Hearings. For an expert consensus system you would not only need a number of experts with different points of view but they must begin from the same assumptions. If they have and maintain different assumptions, they will never reach a consensus.

The consensus system is not a new idea. It was the subject of extensive debate by professors Davis and Cavers in 1962.[4] Professor Caver preferred an open adjudicatory hearing and professor Davis preferred a management executive style review. Professor Murphy, a former ASLB member, notes that executive decisions are fallible. "Ford did, after all produce the Esdel by executive decision."[5]

4) *Conclusion*

The Commission has in the past held generic rulemaking hearings. Both "The Lowas Practicable" and "ECCS" hearings made use of discovery and cross examination.[6]

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[4] Cavers, *Administrative Decision Making in Nuclear Facilities Licensing,* 110 U. Pa. L. Rev. 330 (1962); Davis, *Nuclear Facilities Licensing: Another View, id.* at 371; Cavers, *Nuclear Facilities Licensing: A Word More, id. at* 389

[5] Murphy, *NEPA and the Licensing Process: Environmental Magna Carta or Agency Corp. de grace,* 12 Colum. L. Rev. 963 (1972).

[6] The hearing was a *quasi* adjuciatory hearing. Perhaps such a quasi hearing was permissible there (although we doubt it) it certainly is not permissible here. There must be a fuel adjudicatory hearing.

Our proposal, therefore it is not new. We are only proposing that the generic hearing have concrete guidelines before the hearings starts for discovery and cross examination. As noted previously, the Commission has the authority to establish an orderly procedure. The Commission is not interested and neither are we on who makes the best showing but in ascertaining the truth. Obviously where no purpose is served by cross examination it should be limited. Thus the needless delay and even worse the friction between the parties, which occurs as each issue becomes subject to debate during the hearing on whether discovery and cross examination will be allowed will not occur.

The goal of this proceeding is not to design a system that defines the issues as "legislative", "a adjudicatory," "factual" or "judgemental" but to design a system that permits the parties to make contributions to the resolution of licensing issues.

It may be that the Commission will be tempted to choose adjudicatory hearing and reverse the precedents of the use of discovery and cross examination in generic style hearings. It is our judgment that putting reliance on industry and the staff rather than publicly airing competing points of view is contrary to the purpose of the § 189a hearing:

> to facilitate safety determinations and enhance public confidence in the regulatory process. JCAE, House Report No. 1966 87th Cong. 2nd Session, p. 6 July 5, 1962.

CERTIFICATE OF SERVICE

I hereby certify that a copy of these comments was mailed, postage prepaid this 2nd day of March, 1973, to all persons included on the Service List for this Proceeding.

ANTHONY Z. ROISMAN

STAFF SUMMARY COMMENTS ON PROCEEDING FOR ENVIRONMENTAL EFFECTS OF THE URANIUM FUEL CYCLE, pp. 43-53

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FUEL REPROCESSING

Response to Dr. Geyer's question for types of problems encountered in the Hanford Reprocessing Plants.[21]

The Battelle-Pacific Northwest Laboratories has responsibility to sample and obtain analyses of environmentally important interactions with the Hanford plant. Analyses are performed not only by Battelle, but also by U.S. Testing Company and by the Hanford Environmental Health Foundation, all located at Richmond, Washington. This program of sampling and analysis is designed to demonstrate compliance with various standards, including:

- AEC Manual Chapter 0524 (release limits, Concentration Guides and Population Dose Criteria)
- Federal Air Quality Standards
- Washington State Water Quality Standards,

and to detect any impact of Hanford disposal practices. Both radioactive and nonradioactive chemical analyses are performed.

The most significant Hanford contributions to off-plant radioactivity and population doses have, in recent years, originated with reactor once-through cooling water released to the Columbia River. Beginning in 1971 only one production reactor, N, remains in operation. It has a closed primary cooling loop and releases only minor quantities of radioactivity to the river. Thus, the 1971 Hanford Surveillance Program shows the impact of other Hanford operations on the environment. These operations included the

Purex chemical reprocessing plant, fuel fabrication for N reactor, plutonium processing and scrap recovery, and laboratory operations.

Data presented in BNWL-1688, the 1971 Hanford Surveillance Program, shows conclusively that since shutdown of the once-through cooled production reactors, radioactivity released to the environs at Hanford has been reduced to negligible levels. No unusual releases occurred in 1971 causing Concentration Guides, as given in AEC Manual Chapter 0524, Appendix, Table II, to be exceeded. All measurements of radioactivity were less than 15% of the applicable Concentration Guides. Radiation dose estimates for population groups in the plant environs for 1971 were all less than 1% of applicable standards for plant operations. Offsite measurements of other air and water quality parameters were also well within applicable criteria and showed no significant evidence of plant operations.

Highlights of the observations included:

- Little, if any, measureable effect on Columbia River quality was detectable from wastes released to ground disposal sites within the Hanford plant boundaries.
- Generally, the average airborne radioactivity concentrations at the Hanford boundary were the same as the more distant sampling locations, indicating that Hanford operations were not contributing significantly to offsite airborne radioactivity.
- Average I-131 concentrations in milk locally available were less than 0.5% of the Concentration Guides for water. Increases of I-131 noted in milk for the latter part of 1971 are attributed to atmospheric nuclear weapons testing.
- Cs-137 and Sr-90 were detectable in milk locally available, but concentrations were less than samples ob-

tained from the Puget Sound area — an area of high rainfall; since Richland has a desert climate, the activity is attributed to fall-out.

- Zn-65 activity (250 days half-life) was higher in local farm food-stuffs than commercial foodstuffs and can be attributed to residual activity in irrigation waters resulting from previous reactor operations; however, fallout Sr-90, Cs-137, Ce Pr-144, Zr Nb-95 and Ru-106 activities were higher in commercial foodstuffs than in local farm foodstuffs.

- Plutonium concentrations in soil and vegetation were typical of general regional levels for the arid western states.

Response to CNI/UCS representative's statements about Contamination by Savannah River Facilities and the Skin Dose from Krypton from Barnwell Nuclear Fuel Plant.[22]

Annual reports summarize the results obtained from Environmental Monitoring in the Vicinity of the Savannah River Plant. In the past these reports were issued semi-annually and were entitled "Effect of the Savannah River Plant on Environmental Radioactivity." A continuous monitoring program has been maintained since 1951 (before plant startup) to determine the concentrations of radioactive materials in a 1200 square mile area outside the Savannah River Plant. The quantity of radioactivity released by SRP to its environs is, for the most part, too small to be distinguished from natural background radiation and fallout from worldwide nuclear weapon tests, and environmental levels continue to be far below levels considered significant from a public health viewpoint.

Prospective dose commitments to individuals at the BNFP site boundary from exposure to krypton-85 are:

	mrem/yr.
To surface of skin	21.5
To live skin tissue	11.2
To whole-body	0.28

These dose commitments would result from exposure (continuous for one year) at the location at the site's boundary which would give the maximum exposure to the BNFP stack effluent. These values are not corrected for occupancy factors nor shielding afforded by structures, and represent the maximum annual doses when the BNFP is operating at its designed capacity.

S. H. Smiley also addressed this subject on p. 316 of the transcript and gave the live skin tissue dose.

Response to AIF Comments about I-131/I-129 ratio[18]

Table F-5 in the survey is not in error. The ratio of 10 for I-131/I-129 is the result of applying different decontamination factors to their removal. A lower DF is used for I-129 (we used 600 here) to account for the possible "sneak" iodine which could escape from waste storage or other waste treatment. This information is contained in our backup data. A note to the table will be added to indicate that different decontamination factors are used to arrive at the release figures shown.

Answers to EPA Comments[14]

Iodine Removal Technology

AEC does not agree that iodine removal technology is unproven. The Final Detailed Environmental Statement for the MFRP gives expected release rates for I-131 and I-129 which are 0.1% of the annual inventory of iodine processed. The release rate for I-131 used in the survey is also 0.1% of the processed inventory. The I-129 release

rate was biased upward as described in the preceding paragraph.

Criticality Incident

10^{18} fissions for a criticality is consistent with the Final Detailed Environmental Statement for MFRP. There has never been a criticality accident in a low-enriched uranium fuel cycle facility to date (March 1973).

Low Level Waste

The data on low level waste representing fuel element hulls and other fuel element parts are site independent. The data given in Table F-6 of ES for laboratory waste, small tools, etc. have a wide range (190-1000 cu. ft.) so that any variation between NFS and BNFP operations should be able to be accommodated within that range. The volume of low level laboratory waste, gloves, etc. is a strong function of the way the waste is compacted and packaged.

Concentrations of Radionuclides in NFS Effluents

The following table indicates the NFS experience for the past five years, with respect to concentrations of radioactivity in the liquid effluent to Cattaraugus Creek.

% MPC Measured in Cattaraugus Creek

Year	Max. for One Month	Average for Yr.
1972*	11.0	5.8
1971	n1.2	13.2
1970	49.7	21.9
1969	32.7	19.7
1968**	16.5	10.0

*Through September 1972, later data not yet available.

**Period April-December, 1968

MPC (β) = 3. x 10^{-7} μCi/ml for Sr^{90}

MPC (β) = 1. x 10^{-5} μc/ml for β exclusive of SR^{90}

MPC (α) = 5 x 10^{-6} μci/ml

The effect of operation of the new low level waste treatment system can be seen in the later year's data.

Response to CNI/UCS Statement about I-129[23]

Because of its low specific activity (1.7×10^{-4} Ci/gm) I-129 does not have a serious impact on the environment at the present (Dr. Radford of CNI/UCS accepts this statement). Iodine-129 *was* considered by NFS and the AEC staff has considered the release of I-129 throughout the review and has applied Technical Specifications related to obtaining as low as practicable levels to its release.

Kr-85[24]

Several people have commented about Kr 85 releases given in the report.

The report gives a value for the annual man rem to the northern hemisphere from the release of all Kr-85 from a 1000 MWe reactor over a 20 year period as 80 man rem. If the commitment of 1000 MWe load to a nuclear station were assumed to be a perpetual commitment, the equilibrium exposure to the northern hemisphere from all of the Kr-85 formed in the perpetual production of 1000 MWe would be 120 man rem/yr based on the model 1000 MWe reactor. These values compare with 500 million man rem/year from natural background. Any realistic estimate of installed nuclear power by the year 2000, when multiplied by 120 man rem/year per 1000 MWe, the equilibrium Kr-85 exposure, still yields an insignificant increase over annual background.

It is not the position of the AEC, however, that Kr-85 may continue to be released forever to the atmosphere. There is ongoing research devoted to developing a method for removing Kr-85 from reprocessing plant off-gases.

New York State Comments[25]

New York State Department of Environmental Conservation has commented on the presence of isotopes other than Ru-106 and H-3 in NFS liquid effluents.

Data prior to the installation of improved low level waste systems at NFS are of little but historical value. Stream concentration data for periods toward the end of 1971 show improvement over earlier years.

In considering future releases of radioisotopes from NFS in liquid effluents, the Staff assumed that 10 CFR 20 values would be reached at the waste lagoon discharge for Cs and Sr. Accounting for creek dilution, values offsite would be less than 0.1% of MPC. It is considered by the Staff that Ru-106 and H-3 cannot be removed to the same extent as Cs and Sr. Hence values were assigned for those isotopes.

New York State is correct in that no proof has been introduced that Cattaraugus Creek is not a potential source for drinking water, just as any stream might be a drinking water source. However, it is correct to state that Cattaraugus Creek is not currently a source of drinking water.

Accident Analyses

MPCA has asked for additional data on accidents.[8]

The AEC has prepared a Final Detailed Environmental Statement for the GE Reprocessing Plant at Morris, Illinois and a Draft Detailed Environmental Statement for the Allied-Gulf Reprocessing Plant at Barnwell, South Carolina. Details of accident analyses can be found in these documents or the respective Safety Analysis Reports.

WASTE DISPOSAL

Additions and Corrections to Testimony of Dr. Frank K. Pittman Transcript, page 203, lines 20-25

The waste resulting from reprocessing nuclear fuel in the year 2000 AD is estimated to be contained in approximately 8,000 waste cans (typically 1 ft. diameter by 10 ft. long). Assuming this waste is stored at the reprocessing plant for 10 years, the waste would be received at a Federal repository in about 630 shipments during the year 2010 AD.

Transcript, page 204, lines 12-13

Assuming no technological changes in the methods of power generation or improvements in nuclear waste concentration or reprocessing methods, between 2000 AD and 2025 AD, the estimated number of shipments of "typical" waste containers to be received at a Federal repository in the year 2000 AD (~25 years hence) is about 260 shipments per year and for the year 2025 AD (~50 years hence) about 1250 shipments per year.

The estimated number of annual shipments (assuming 12 "typical" waste cans per shipment) are given for the following years:

Year	Estimated Annual Shipments Received at Federal Repository
1985	20
1990	70
1995	140
2000	260
2005	420
2010	630
2025	1250

Other-Than-High-Level Wastes

EPA[14] and MPCA[8] have commented on other-than-high-level waste in the form or reactor generated material. Other than high level reactor waste (e.g., circulating crud, IX resin) is not a part of this survey since it is covered in individual reactor statements. It is not felt that residual activation products on or in reactor fuel assembly cladding effectively changes the character or amount of radioactive materials in the reprocessing plant.

High Level Wastes

The AIF has pointed out a typographical error in the survey.[18] The value given on page G-10 of the ES should be 10,000 gallons of radioactive liquid waste.

In the Matter of	
AMENDMENT OF 10 CFR PART 50-LICENSING OF PRODUCTION AND UTILIZATION FACILITIES (Environmental Effects of the Uranium Fuel Cycle)	Docket RM 50-3

SUPPLEMENTARY COMMENTS BY THE UNION OF CONCERNED SCIENTISTS ON "ENVIRONMENTAL SURVEY OF THE NUCLEAR FUEL CYCLE"

The enclosed comments on 1. the storage and disposal of high-level radioactive wastes; and 2. the operations of the fuel reprocessing plant located in Ashford, New York, operated by Nuclear Fuel Services, Inc., are being filed with the Atomic Energy Commission in behalf of the Consolidated National Intervenors by the Union of Concerned Scientists as part of its testimony in the rulemaking hearing (Docket RM 50-3) held in Washington on February 1, 1973.

INTRODUCTION

The following chapters specifically address two important areas of major public concern. Both of these topics are treated, albeit briefly, in the document *Environmental Survey of the Nuclear Fuel Cycle* (ESNFC) and are recognized by the Atomic Energy Commission as being important parts of the fuel cycle whose costs and benefits are to be determined as accurately as possible for use in the licensing of nuclear power plants.

The treatment of the following discussions is limited solely to the radiological effects of fuel reprocessing and waste storage. Although there are additional environmental impacts in the form of land use, chemical effluents, and thermal pollution, it is clear that the unique hazards of public concern — whose costs are especially to be evaluated — arise from the presence of enormous amounts of radioactivity.

FUEL REPROCESSING

At this time there is extensive experience with only one reprocessing plant in the United States, located near West Valley, New York. The description of the experience with this plant, as presented in the ESNFC, is deficient in evaluating the radiological and environmental effects, including those on wildlife, from the recorded radiological emissions. Much of this problem stems from the lack of adequate surveillance and monitoring in the environs of the plant. These issues are explored in depth in chapter 3 of this report with appropriate recommendations for reducing emissions and providing an adequate monitoring program in the future. It is clear from chapter 3, however, that the environmental costs of the operations of the NFS reprocessing facility have been underestimated by the AEC.

WASTE STORAGE

One of the most important issues facing the use of nuclear energy today is the problem of ultimate disposal of highly radioactive wastes. If this problem continues to remain unsolved, as it surely is today, one would have to conclude that the environmental and social costs of using nuclear energy are so great as to be prohibitive. Yet the treatment of this immensely important topic in ESNFC is superficial and inadequate. For example, there is an *exclusive* description of radioactive wastes in chapter G in

units of cubic-feet, as though high-level wastes were so much sand or gravel. Such a description, without a further elaboration of the potential impact of a cubic-foot of wastes, is misleading and useless. In addition, Chapter G of ESNFC, on waste storage, is replete with bland reassurances that problems can be solved even though the full extent and seriousness of these problems are not presented and explored. Consider the following statement: ". . . the Federal government plans to provide an engineered structure facility for interim storage of high-level wastes. This interim facility will be designed with capability for storage of wastes for a 100-year period." (p G-2). No further elaboration is given. Later, ". . . The engineered facility will be designed so that solid high-level wastes can be stored without danger to the health and safety of man and with no unacceptable impact on the environment." (p G-11). Little can be said about such an all encompassing statement.

In Chapter 2 of this report the full environmental implications of the waste storage problem are explored. Various proposals are reviewed and recommendations are presented for urgently needed research. As with fuel reprocessing, one can only conclude that the social and biological costs of accepting the hazards of storing high level wastes forever have been grossly underestimated by the AEC.

The following chapters of this report have been prepared by Prof. Thomas Hollocher, Department of Biochemistry, Brandeis University, and Philip M. Hatfield, M.D., Lahey Clinic Foundation, Inc., Boston.

In oral testimony at the AEC hearing on Environmental Effects of the Nuclear Fuel Cycle, UCS emphasized that it was particularly important to assess, at once, full environ-

mental impact of all operations associated with radioactivity and nuclear fision. Especially UCS emphasized the importance of considering the question of catastrophic accidents in nuclear reactor operation. The importance was stressed of setting out the probability and consequences of such accidents and comparisons with the assurances that have been made public by the reactor vendors, the AEC, and the utilities. In oral testimony UCS stated its position concerning accident probabilities and consequences based on its own analysis and on its participation in the ECCS hearings. We wish to emphasize the importance we attach to having the Environmental Survey include this material. In no other way can the impact of the nuclear program be adequately assessed. UCS established in its oral testimony the great present risks borne by the American public owing to the very grave deficiencies in the regulatory reviews of reactor safety and the consequent dwindling and vanishing of necessary margins of safety.

There is no mention in the Environmental Survey of the special risks and problems associated with the recently announced reactors which will float at sea. UCS has given oral testimony to a sub-committee of Senator Warren Magnuson's Senate Commerce Committee, under Senator Hollings, February 1, 1973. The risks include not only extra difficulties in the case of catastrophic accident but also new difficulties in the transportation of irradiated fuel. This latter subject is not treated adequately in the AEC's Environmental Summary of November 1972.

STORAGE AND DISPOSAL OF HIGH LEVEL WASTES

I SUMMARY AND RECOMMENDATIONS

II HIGH LEVEL RADIOACTIVE WASTES AND THEIR DECAY CHARACTERISTICS

III GROWTH OF NUCLEAR POWER

IV INTERMEDIATE AND LOW LEVEL WASTES

V EXPERIENCE WITH WASTES FROM NUCLEAR WEAPONS PRODUCTION

VI STORAGE/DISPOSAL PLANS IN THE NUCLEAR POWER INDUSTRY

1. Short term storage for thermal decay
2. Disposal in solar orbit
3. Transmutation and fission of transuranic actinides
4. Deposition in oceanic trenches
5. Disposal in Antaretica
6. Desposition in underground caverns created by the detonation of nuclear devices
7. Burial in ancient bedded salt formations or dry rock at intermediate depths
8. Deep burial
9. Injection of wastes in liquid form into wells
10. Long term storage in surface structures

TABLE I

TABLE II

TABLE III

LEGENDS TO FIGURES

FIGURE I

FIGURE II

FIGURE III

I SUMMARY AND RECOMMENDATIONS

Except for the storage of liquid wastes in tanks, for which experience from weapons production applies, all proposals for long term storage or disposal of high level waste from the nuclear power industry lie at the research and development stage. The proposals so far considered seriously by the AEC for the disposal of wastes are dubious in concept (caverns excavated by nuclear weapons, depositing wastes in liquid form in rock caverns), not technically feasible (disposal in solar orbit), or they are so dependent upon site specific geological characteristics that suitability cannot be determined *a priori* without extensive on site investigation (disposal in bedded salt or under Antarctic ice). One such site, the salt beds at Lyons, Kansas, was studied carefully for several years in the 1960s and was finally adjudged unsuitable. The matter of man-made vaults at or near the surface for long term storage (500 years) is equally uncertain. Their maintenance depends upon the existence of social and political institutions, the permanence of which cannot be guaranteed over time.

The impression is inescapable, in view of the present imprecise state of affairs, that no convincing statements exist regarding the long term environmental impact attending the storage and/or disposal of wastes from fuel reprocessing. It is disturbing in this regard that the pace of development of a suitable waste disposal technology does not seem commensurate with the rate of expansion of the nuclear power industry. This situation is reminscent of developments attending the production of plutonium for the weapons program: Hasty and, in part, seriously incorrect decisions were made regarding the storage of wastes produced by a technology alleged to be urgently necessary.

The times during which radioactive wastes must remain secure from the biosphere have no parallel in human affairs.

Eight hundred years are required for fission products alone and millions of years if the fission products continue to be contaminated with transuranic elements at present levels. Fission technology requires that man issue guarantees on events far into the future, and it is not clear in most cases how this can be done. Institutional arrangements do not exist and never have existed to guarantee the monitoring of or attendance upon storage facilities over a millennium. In the range of a million years, serious geological uncertainties arise and even the survival of man may be doubtful. "In perpetuity" has little real meaning in human affairs.

The uncertain state of affairs in high level waste disposal was well summarized in 1972 by F. K. Pittman, director, Division of Management and Transportation, U.S.A.E.C.:

> "While none of the suggested long-term solutions to the problem of permanent disposal of high-level radioactive waste is technically or economically feasible today, the AEC recognizes that one or more may well offer attractive options in the future." (21)

It is interesting to note that AEC regulation now stipulates that high level wastes are to be solidified after 5 years storage and shipped to a Federal repository within 10 years. The repository does not now exist and may not exist for some time. In the meanwhile, billions of Curies from commercial power production will join the accumulated several billion Curies of weapons waste — all of it at the earth's surface and vulnerable to accident, error, or sabotage.

It is probably advisable, given the scale of anticipated nuclear operations, to increase the budget for research and development in waste management. Through the 1960s to 1971, the AEC budget for this category was about $5 million/year. Of that, about $½ million/year went to salt disposal, specifically the Lyons, Kansas project, about $2 million/year was committed to waste solidification tech-

nology, and about $2.5 million/year has been used to develop a rock cavern disposal scheme for the Savannah River plant. This $5 million can be compared with a total yearly waste management budget in the AEC of about $35 million, most of which goes to management of weapons wastes. For orientation, the entire AEC budget is of the order of $3 billion/year.

RECOMMENDATIONS

1. The chemistry of fuel reprocessing should be improved to separate almost totally the long-lived transuranium elements and other actinides from fission products. Levels of actinides should be reduced by 10-fold for some, and 100-fold for others relative to present levels in the reprocessing waste stream. The extraction of U, Np, and Pu should be 99.95% complete and that of Am and higher actinides should be 99% complete. This will result in increases in the cost of fuel reprocessing and, together with Recommendation 2 below, lead to an increase of about 2-3% in the cost of delivered nuclear power. At present, for comparison, the only actinides recovered are U and Pu, both at the 99.5% level.

Similar improvements should be made also in cleaning up fuel cladding hulls and α wastes from fuel fabrication.

2. Recovered transuranic elements should be disposed of through their transmutation and fission, preferably in fast neutron reactors. This would diminish the time of hazard for the remaining fission products to something of the order of 800 years, as opposed to millions of years otherwise.

3. The remaining fission products should be solidified in a time as short as is consistent with radiogenic heat production, and certainly no greater than 5 years, and be placed, as soon as is practicable and safe, in carefully se-

lected geological formations. The possibility that solidification can immediately follow reprocessing of fuel should be vigorously pursued, for this would eliminate interim tank storage of liquid wastes.

4. Long term (>50 years) storage of fission products in surface or near surface facilities should not be undertaken.

5. Disposal plans which are attractive in principle but at present unfeasible (disposal in solar orbit) or in need of further study (disposal under the Antarctic ice cap) should be reviewed periodically in light of relevant technological developments or new data.

6. In light of the impending need for a Federal waste repository, a greatly increased research and development effort toward that end should be undertaken by the AEC and the relevant industrial authorities. A detailed plan for the disposal of high-level wastes through 2000-2010 A.D. ought to appear within the next few years.

II HIGH LEVEL RADIOACTIVE WASTES AND THEIR DECAY CHARACTERISTICS

During the operations of a reactor, two main types of radioactive products accumulate in the fuel: fission products and actinides, the most abundant of which are the transuranium elements. Actinides are the series of elements Ac, Th, Pa, U, and the transuranium elements starting with Np, Pu, Am and Cm. Fission products, as the name implies, are the products of the fission of ^{235}U and, to some extent in light water reactors, of ^{239}Pu and ^{241}Pu, and have mass numbers in the range 8-155. The transuranic elements are built up by neutron capture, starting with ^{238}U, and include fissionable and fertile isotopes of Pu which are of value as nuclear fuel. The transuranic elements of major importance here have mass numbers from 237-244.

In irradiating enriched uranium fuel in a light water reactor to the level of 33×10^9 watt-days per metric ton fuel, about 33 kg of U is consumed (converted to fission products) per metric ton and there is present at the end 8-9 kg of Pu and about 1 kg of other transuranic actinides, most of which is Np.[1]

During fuel reprocessing the fission products are separated, and uranium and plutonium are recovered. The separations are not quite total under present chemistry (Purex and related processes) and about 0.5% of the Pu and U and most of the other actinides appear with the fission products in the final aqueous waste stream. Typical values for the yields of fission products and transuranic elements in the reprocessing waste stream are given in Tables I and II, respectively. In addition, about 0.1% of the Pu remains with the fuel cladding hulls. Some also appear as α wastes in fuel fabrication.

It is clear that both the short lived products ($t_{1/2} < 1$ year) and the very long lived isotopes ($t_{1/2} > 10^7$ years) are of little concern in the context of long term storage and disposal. The former decay largely within the period of thermal cooling of 3 to 5 years which can be considered temporary storage; the latter decay so slowly that they exhibit low specific activities and rather low radiological hazards. ^{129}I ($t_{1/2} = 1.7 \times 10^7$ years), for example, has a specific activity of only 0.16 mCi/g and would not represent a major biological hazard even to thyroid tissue if it were diluted with stable iodine to the level of 1 part in 10^5 - 10^6 (2). In Tables I and II, therefore, we have considered only products with half-lives > 1 year and (except for ^{129}I) < 10^7 years.

The high initial radioactivity of fission products is occasioned by short-lived isotopes. If total decay energy of fission products at age 1 day were taken as 100, then the value would drop to 10 at 100 days, to 1 at about 900 days, to 0.3

at 10 years, and to 0.1 at about 41 years (3). At 5 years, the total decay energy is only about twice that for ^{90}Sr and ^{137}Cs combined, and, as seen in Table I, these two isotopes contribute the bulk of the decay energy at ten years. By 500 years, the decay energy has dropped another 4 orders of magnitude relative to that at 10 years and is now dominated by ^{151}Sm. A further factor of decrease of about 2 is realized by 1000 years at which time ^{93}Zr, ^{99}Tc, and ^{135}Cs dominate. Thereafter decay is very slow and is governed by isotopes with half lives $> 2 \times 10^5$ years. In summary, fission product decay energy drops by a factor of several million after 800 years relative to the value at 1 day.

While fission products are not without hazard after 800 years, the relative toxicity is only about 50 times that of a similar volume of natural uranium ore containing 1.4% U_3O_8 by weight (4).

We define relative toxicity at different times according to the approach of Kubo and Rose (4). For each radioactive species, a water dilution factor is computed so that the species would be present at no more than the maximum permissible concentration set by national standards. The dilution factors, summed over all the species, are then compared with the dilution factor for uranium ore of the above type, which serves as a nonzero but commonly encountered source of radioactive isotopes in the lithosphere. The reprocessing wastes are assumed to be solidified at 1 ft^3 per 10×10^6 watt-day (thermal) operation of the reactor. This approach takes into account both the direct radiological hazards and the biological factors, such as body turnover and organ specific sequestration, that are believed to apply in men. It does not consider more complicated factors, such as concentration mechanisms which often apply to isotopes as they pass through a series of ecological food chains.

The problem with the transuranic elements is more difficult. Elements of the group decay by α and/or β emission through numerous steps into other radioactive daughter elements (e.g., ^{244}Cm into ^{240}Pu); and they have generally very high biological toxicity by virtue of α emission and biological sequestration. Three disintegration processes are of importance in Table II:

$$\text{Cm-244} \xrightarrow[\alpha]{17.6\ \text{yr.}} \text{Pu-240} \xrightarrow[\alpha]{6580\ \text{yr.}} \text{U-236}$$

$$\text{Am-243} \xrightarrow[\alpha]{7370\ \text{yr.}} \text{Pu-239} \xrightarrow[\beta-]{2.35\ \text{day}} \text{Np-239} \xrightarrow[\alpha]{24400\ \text{yr.}} \text{U-235}$$

$$\text{Pu-241} \xrightarrow[\beta-]{13.2\ \text{yr.}} \text{Am-241} \xrightarrow[\alpha]{462\ \text{yr.}} \text{Np-237} \xrightarrow[\alpha]{2.2 \cdot 10^6\ \text{yr.}} \text{Pr-233}$$

The second series of decays generates Pu-239 and is particularly relevant to very long term storage. One decay path of long term interest not shown in Table II is the decay of Pu-238 into U-234 which itself has a half life of ¼ million years.

Plutonium (Pu) is perhaps the most toxic element known and represents a chronic biological hazard on a weight basis comparable to the acute hazard from *botulinus* toxin, i.e., it is hazardous at 10^{-6}g, if appropriately deposited in lungs or bone (5). ^{239}Pu in equilibrium with its daughters has a direct radiological hazard about 10,000 times that of natural uranium in equilibrium with its daughters (6). Pu exhibits, in addition, a very large biological concentration factor with little turnover in bony tissues. The yields of ^{239}Pu and ^{240}Pu from one metric ton of fuel in Table II represent together about 70g of Pu after 500 years storage. It is clear that the presence of current levels of transuranic elements alone in the waste stream will require that the wastes be secured from the biosphere for very long periods.

The period of hazard for the waste actinides is determined in the long term by the properties of the radioactive daughters. The decay energies of the actinides and their daughters decrease with time and become equal to those of fission products after a few hundred years, as shown in Fig. 1. Thereafter the actinides dominate. The relative toxicities of the decay daughters tend, however, to be somewhat greater than the parent actinides (4). As seen in Fig. 2, the relative toxicity goes through a minimum at about 2×10^4 years and then increases about 7 fold and reaches a maximum at about 7×10^5 years. Relative toxicity remains more than 1000 times that of uranium ore over most of 4×10^6 years.

III GROWTH OF NUCLEAR POWER

An example of a projection on the growth of the nuclear power industry in the U.S. is given in Table III. Various projections have been made and, while some disagreement is noted, the projections generally agree within a factor of about 2 (1, 6, 7, 8).

It seems likely that 700-1000 reactors will be in operation by the year 2000, each with an output of about 1 Gw(e) (1,000 megawatts) or 8000 Gw-hrs (e)/yr. This is a level of about 140 times the output of the present nuclear power industry. Each reactor will generate 5-8 metric tons of solidified high level waste per year at steady-state to yield in total about 5000 metric tons of waste per year. Accumulated wastes will be about 25,000 metric tons by the year 2000, or, if left as aqueous liquid waste, 40-60 million gallons. Accumulated radioactivity has been estimated to lie in the range of 200 billion Ci, with about 30 billion Ci residing in high level waste which has aged for 5-10 years. The accumulated ^{239}Pu alone would amount to about 24 metric

tons total in the waste. The capital investment for the plants alone is estimated to be about $300 billion. Sales of nuclear-generated electricity at 8-9 mills/kw-hr. will result in a $60-70 billion/yr. industry.

IV INTERMEDIATE AND LOW LEVEL WASTES

A second class of nuclear waste exists which contains radioactivity at much lower levels — the so-called low and intermediate level wastes (1, 7, 9). These are comprised largely of solutions and materials which have become contaminated with various but generally small amounts of fission products and/or transuranic elements as the result of processes or accidents within the nuclear industry. An important source of these wastes in the power industry will be the fuel cladding hulls which contain activitation elements and some residual Pu. The problem of disposal of low and intermediate level wastes lies not so much in the amounts of radioactivity, which are small compared to those arising directly from fuel reprocessing, but rather in their large volume and varied form.

Low and intermediate level wastes have been disposed of variously since the onset of nuclear weapons production: direct release to surface waters or discharge into the ground by seepage in the case of aqueous solutions; shallow burial of solids in both recoverable and nonrecoverable forms. The chief problems concern the reduction of bulk, which, for some material, can be accomplished by combustion and fluxing of the solid residue at high temperatures.

While not perhaps a major problem, it is clear that a large nuclear power industry could deposit potentially large and serious amounts of radioactive materials in low and intermediate wastes. It is important that the disposal

of these wastes be very carefully considered. Some lower level wastes can be reduced in volume and ultimately added to high level wastes for long term storage or disposal. For other materials, separate disposal facilities may be in order. Fuel cladding hulls may represent a special problem in the long run. About 1/6 of the unrecovered Pu (8-9g Pu per metric ton of fuel reprocessed) remains with the hulls (1, 7). It may prove advisable or necessary to make the recovery of transuranic elements from the hulls nearly complete.

V EXPERIENCE WITH WASTES FROM NUCLEAR WEAPONS PRODUCTION

Since the inception of the nuclear weapons program during World War II man has had to deal with the problem of handling and storing high level nuclear wastes. We now have in storage from the weapons program about 90 million gallons of liquid waste and an accumulated total of several billion Ci of fission products (9). The material must be considered to be under temporary storage. In retrospect, it is now clear that mistakes were made early in the technology of storage of high level wastes arising from the weapons program. It is interesting that the mistakes were occasioned, in part at least, by the fact that hasty decisions and shortcuts were forced by what seemed to be the overriding national need for bomb-quality plutonium. It is not necessarily true that all facets of a new technology can be forced into efficient operation at the same rate. The lessons learned as the result of weapons technology should be carefully applied in the nuclear power industry.

High level fission products from fuel reprocessing are thermally hot initially and are stored temporarily in water which is cooled either by refluxing or by refrigeration.

The products partly dissolve and partly form slurries depending on their solution chemistries and ph. After 3 to 5 years, the rate of heat production has dropped to the point where the water can be removed and other long term storage or disposal strategies can be considered.

The bulk of wastes from nuclear weapons production are stored as neutral or alkaline solutions/slurries in underground carbon steel tanks, with lesser amounts stored as acid solutions in stainless steel tanks, especially at the Idaho Chemical Processing Plant. The Hanford, Washington, and the Savannah River, S.C. facilities house, between them, most of the high level liquid wastes (1, 9).

The approximately 90 million gallons of waste are stored in some 200 tanks with capacities between 0.3 and 1.3 million gallons, encased in concrete and surrounded by earth under shallow burial. The capital costs for the tanks range between $.50/gallon for 1.3 million gallon carbon steel tanks without cooling facilities, to $5.40/gallon for 0.3 million gallon stainless steel tanks with cooling coils and agitators (1).

While the tanks had life expectancies in excess of 50 years, the combination of heat, radiation, high salt concentrations, and mechanical stresses (especially at welds) has resulted in tank failures and unexpectedly short operational lives. As of 1970, 15 tank failures had been reported, all in carbon steel tanks at Hanford and Savannah River (1). The 11 failures at Hanford have released an estimated 140,000 Ci of mainly ^{137}Cs to the ground beneath the tanks. The bulk of this activity is believed to be retained by the soil 3-5 m below the tanks. A total of 4 lesser failures have occurred at Savannah River. In addition, one release was reported at Savannah River involving about 2000 Ci of ^{137}Cs during an accident in a transfer operation. The waste

was released into a sewer and thence partly into a connecting stream. No leaks have been reported in the stainless steel tanks at the Idaho plant over 16 years, but severe pitting and weld corrosion has been noted.

In the case of tank damage, the remaining contents are pumped to another tank and the damaged tank is withdrawn from operation or sealed. Stainless steel tanks can be stripped of residual solids and scale by acid washes, and therefore can be largely decontaminated. Carbon steel cannot easily be cleaned be acid with which it reacts. Thus, satisfactory methods may not exist for removing solids and scale completely from carbon steel tanks for decontamination. A combination of materials scarcity and cost resulted in the construction of most tanks from carbon steel rather than from stainless steel. This is in retrospect a serious mistake involving considerable hazard and additional major costs which have yet to be evaluated.

The total AEC waste management budget in the 1970s, exclusive of research and development programs, has been running about $35 million per year. The management of nuclear weapons wastes now stored in tanks may in the long run cost an additional $1 billion.

Programs are now underway, but have not proceeded very far, to convert weapons waste from liquid form to other forms and thus to phase out tank storage. At Hanford, the main heat producing isotopes, ^{90}Sr and ^{137}Cs, are being stripped out, encapsulated, and stored under water. The remaining wastes are then concentrated or solidified to salt cake. This program is connected to another proposal to deposit the salt cake or dense slurry into caverns in the basalt underlying the site. Environmental objections to this plan have been major and its future is very much in

doubt (10). A similar plan to deposit dense slurries in the gneiss and sedimentary formations under the Savannah River plant has been under study since 1960. At the Idaho plant, wastes are being calcined to granular solids and stored in stainless steel bins in underground concrete vaults to await final disposal. Of about 4 million gallons of liquid waste generated at the Idaho plant, about 2 million gallons have been converted to solid form over the past ten years.

VI STORAGE/DISPOSAL PLANS IN THE NUCLEAR POWER INDUSTRY

Within a decade, accumulated wastes from nuclear power generation will be in the billion Ci range and reach tens of billions of Ci by the turn of the century. It is clear that indefinite tank storage is unsatisfactory and expensive; on the other hand, proposals for alternate long term storage programs and for permanent disposal methods are still in the research and development state. Waste storage and disposal represent certainly two of the most crucial problems facing the nuclear power industry. Incorrect decisions in this decade could lead to enormous expenses in the next two decades and possibly even to a crippling of the nuclear power industry.

The billions of Ci of high level wastes expected over the next 30 years must not under any circumstances by released into the biosphere. At present only three disposal options seem open: a) the wastes may be removed from the earth, b) they may be contained on or in the earth for sufficient periods — 800 years for fission products and million of years for transuranic actinides — and, c) the transuranium actinides may be transmuted to fissionable isotopes and destroyed by fission. In the following we shall evaluate these various proposals for storage and/or disposal.

For the purposes of definition, "storage" implies retrievability, i.e., mistakes can be corrected in principle; "disposal" implies irretrievability. In passing we should mention that transmutation of *fission products,* as opposed to transuranic elements, to stable isotopes is entirely impractical.

Storage and disposal (in the earth) are two very different stratagems. Storage retains future options and provides safety against error, but requires full societal responsibility. Disposal guards against an irresponsible society but offers the possibility of environmental hazard at some future time. Decisions regarding storage and disposal are by no means entirely technological. They are to a large extent societal in nature and relate to very uncertain matters: the stability of societies over time; the extent of responsibility we have over future generations of man and even over the biosphere generally. In addition, there is a desirable economic goal that waste management in the power industry should cost only a small fraction of the cost of delivered electricity.

1. Short term storage for thermal decay:

The rate of heat production in high level wastes after 5 years of storage is about 0.6% of that encountered one day after the termination of fission in the reactor. ^{90}Sr and ^{137}Cs are the two principal abundant isotopes decaying at this point in time. Wastes during this early period of storage have been and continue to be kept as aqueous solutions/slurries in tanks, and this method appears to be generally satisfactory for short term storage. There are a few design features, however, which deserve considerably more attention:

a) The tanks should be so located and constructed that they will be secure from rupture by surface detonation of thermonuclear weapons;

b) They should be located in or on dry, highly impervious rock as remote as possible from active faults, mobile underground water, and aquiters;

c) The tanks should be designed for thorough decontamination in the case of damage or deterioration and should possess multiple containment barriers each one of which can be decontaminated and repaired; and

d) If left unattended, the tanks and secondary barriers should secure the contents for at least 500 years against the usual ravages of time.

It seems advisable in any case for the initial storage in water to be as short as possible. Water is a highly mobile fluid and requires a strong structure for containment; the chemical reactivity of aqueous solutions/slurries of intensely radioactive wastes is high. It should be possible to remove water after 1 to 3 years and reduce the waste to some suitable stable solid form. The form may have to be granular initially to permit better heat dissipation, but clearly it can be converted to a bulk glass or ceramic after 3 to 5 years. Studies by the AEC suggest that wastes may be solidified in granular form immediately after fuel reprocessing (i.e. after 0.3 years), thus obviating tank storage (1, 9). This research should be pursued vigorously.

2. *Disposal in Solar Orbit:*

By the year 2000 it is expected that the entire U.S. nuclear industry will be producing the order of several thousand metric tons of high level waste products per year. It is conceivable that this material could be placed in solar orbit by a group of some tens to 100 large boosters or by some alternate series of space station shuttles and interplanetary boosters (6). This plan is both expensive — costing perhaps $5-10 billion per year by 2000 — and currently unfeasible. The probability of failures which could lead to atmospheric reentry must be essentially zero and, in

addition, pay loads must themselves be designed to survive reentry and impact in an intact and recoverable state. The vaporization of even 10^6 Ci of long-lived high level waste products in the upper atmosphere would be a serious event leading probably to significant radiation doses to the lungs of man and animals. Our only experience with the reentry of radioactive material involved the disintegration in April 1964 of a SNAP thermoelectric satellite which contained 17,000 Ci of ^{238}Pu (about 900 g). It is estimated that this relatively small release of radioactivity will result in a cumulative 50 year dose to the lungs of adult humans of about 36 millirem (about 1/3 of one yearly dose from background radiation) (11).

The idea of disposal in solar orbit is satisfying in its simplicity and finality and should be reviewed periodically in light of developments in space technology.

3. Transmutation and fission of transuranic actinides:

Various proposals exist for storing wastes on or in the earth for whatever times are required for decay to non-hazardous levels. Inherent in these plans is the idea that man must bear responsibility for actions over times that are long compared with the lives of nations. The requisite social and legal institutions simply do not exist to assure responsibility over periods of 800 years (fission products) upward to millions of years (actinides). It seems prudent, therefore, to do everything possible to minimize the time required for the wastes to decay to safe levels. The one process which will decrease containment time by more than 3 orders of magnitude — from several million years down to 800 years — is nearly total removal of transuranic elements (4, 12).

At present the recovery of U and Pu from fuel reprocessing is 99.5% and most of the other actinides are not re-

covered. This compares with a technological limit for extraction of actinides from the waste stream of about 99.9999% (Ac through Pu) and 99% for Am through Es. As can be seen in Fig. 3, *such complete extraction would lower the long term relative toxicity by 3-4 orders of magnitude compared with current practice.* Extraction of 99-9%-99.95% U, Np, and Pu and of 99% Am and Cu (middle curve) can be accomplished realistically and would result in a long term actinide hazard about equal to that for fission products, which is considered to be small.

If the recovered actinides were burned up by recycling through a light water reactor, the additional costs for improved extraction plus burn up would be about 1.5 times that for current fuel reprocessing and result in an increase in delivered electricity of about 0.3 mills/kw hr. (e) on a base of 8-9 mills kw hr (e) (4). It is believed that light water reactors would not have to be altered much, except to increase ^{235}U enrichment slightly, in order to burn up actinides by fission. A much better route would be to burn up actinides in fast neutron reactors where the fast neutron spectrum is much more efficient than thermal neutrons in transmuting actinides to fissionable isotopes. If fast neutron reactors were used, the cost increment on electricity is estimated to be only 1% or less for improved extraction and burn up. At steady state, about 1 part in 7-10 of the fuel in a Pu-fueled liquid metal fast breeder reactor would be actinides other than Pu.

Geological burial or other disposal schemes would still have to apply to the fission products. The increment of cost cited above, therefore, is in excess of the cost of disposal of fission wastes, the costs of which may be expected to lie in the range 0.005-0.008 mills/kw hr (e).

The alternative is the continued production of waste material so laden with Pu and other long-lived transuranic

elements that confinement periods of millions of years will be necessary. While secure storage or burial may well be possible for periods of 800 years for the decay of fission products, this is not necessarily the case for periods thousands of times this. Within one million years, another ice age could occur, continental erosion of hundreds of meters is likely, and even the species man could become extinct.

If the transuranic elements were removed almost completely, then *storage* in massive surface vaults for 800 years or any one of a number of deep burial schemes — e.g., in ancient bedded salt deposits — become feasible. If the problem is one of the *disposal* of transuranium elements, then surface vaults are excluded and some schemes for geological burial, including the now favored burial in salt mines, become of questionably security.

4. Deposition in oceanic trenches:

Oceanic trenches represent lines along which one oceanic plate is sinking beneath the adjoining plate into the mantle of the earth. Ocean sediments accumulate to great depth in trenches and subside, in part at least, with the sinking plate, which may descend at rates of the order of 1 cm/year. Thus, anything deposited in the sediments of the trench must become more deeply embedded by virtue of mechanical locking with the descending plate and the continuing deposition of sediments and must eventually be ingested into the mantle of the earth.

An objection to the disposal of wastes in oceanic trenches arises from the fact that the radioactive wastes might be exposed to an aqueous environment — seawater and/or wet sediments for long periods of time during which they will still generate significant amounts of heat. The possibility of radiolytic decomposition of containers and the possible loss of material by accidental sinking away from the trench

introduce considerable risk even for the disposal of fission products. The method is appealing in that confinement forever is guaranteed, providing only that the method of initial implantation totally and irreversibly separates the radioactive material from the oceanic environment. This method should be reviewed periodically.

5. Disposal in Antarctica:

Ice, like salt, exhibits plastic flow at modest pressures and is self-sealing. This property and the inaccessibility of the antarctic interior prompted Philbert (13) to propose disposing of high level wastes deep in the Antarctic ice cap, probably at the ice-rock interface. The wastes, in an encased vitreous form, with dimensions 0.3x3 meters, and heat output of about 5,400 watts, would be allowed to melt their way into the ice and slowly sink to the ice-rock interface (14). It would take an estimated 3-5 years to sink an expected 1.5 km to the interface assuming an ambient ice temperature of about −50°C. On the high central plateau around the Pole of Inaccessibility, the temperature at the ice-rock interface is estimated (but not as yet directly measured) to be −20 to −30°C. This region therefore probably has no free water at or near the interface. The absence of water is crucial to the plan since there must arise no possibility of channels of communication between the deep interior ice and the sea, some 600-1000 km away.

The ice of Antarctica appears to be very stable and ancient. Data on ice cores from "young" ice taken from an active ice stream near Byrd Station suggest an ice age of about 0.1 million years at depths of 2.2 km. Other studies show that the average temperatures in Antarctica have remained below freezing for more than 1 million years. On the other hand, some believe that very extensive lateral flows or "surges" of ice have occurred roughly every 10^5 years during the Pleistocene age. These would be expected

to thin the ice cap considerably and forcefully scour the continent. Material from the ice-rock interface of the interior might be transported to the sea rapidly in a "surge." Sites would be selected according to rock topography so that transport would be minimized in the event of a "surge." In any case, the enormous heat of fusion of the ice sheet alone implies a general stability for the future. Antarctic ice contains a heat of fusion equivalent to the entire solar input to earth over about 100 years.

The repository area could probably cover some 40,000 km^2, so the waste containers could be deposited sparsely to avoid a general heating of the ice. One 5400 watt container per km would contribute only 10% of the local geothermal gradient ($\sim 1.2 \times 10^{-6}$ cal/cm^2/sec.). It is probable that permafrost extends deeply into the rock in central Antarctica — perhaps to depths of 0.5-1 km — so that there is essentially no mobile ground water. Perhaps a safer alternate plan would be to emplace waste containers deep into the permafrost rock and effectively decouple them from all possible future motions of the ice.

The proposals regarding disposal in ice are attractive and ought to be pursued. Security for 800 years seems certain. Moreover, the present international character of Antarctica may permit it to serve as an international repository.

6. Deposition in underground caverns created by the detonation of nuclear devices:

This proposal (15) involves the introduction of fresh high level wastes as aqueous solution/slurry into a cavern formed 1000-2000 m underground by the explosion of a nuclear device. Rock is a poor conductor of heat and initially self-distillation, perhaps into surface heat exchanges, would serve to cool the wastes. Finally, after sufficient decay, the material would be allowed to dry and finally to

fuse with the rock to distribute the wastes within a natural silicate matrix. The hazards of this method lie first in the extensive and unpredictable fracturing of rock in the vicinity of an underground nuclear explosion — even to the surface. There seems to be no way to assure the absence of channels of communication between the cavern and the surface or underground aquifers. The explosion may serve also to release geological strain locally. Thus, minor faulting may occur out to a distance of from one to a few km from the site and offer additional channels. The advantage is that the method is quick, inexpensive (perhaps 0.01 mills/kw hr), and can accommodate fresh waste directly from the reprocessing plant. If each reprocessing plant could be supplied with such sites, the transportation of high level wastes could be obviated.

On balance, the plan seems very much more hazardous than others.

7. *Burial in ancient bedded salt formations or dry rock at intermediate depths:*

The method of disposal in bedded salt has been the subject of NAS studies (16) and the AEC has carried out extensive tests in the late 1960's at a salt mine at Lyons, Kansas (7, 17, 18). The 100 m thick formation is of Permian origin about 250 Million years old and lies at a depth of 300 m. The plan involves the deposition of radioactive waste in the form of metal encased ceramic cylinders about 25 cm in diameter and 3-5 m long into thick salt strata located at depths of the order of 300 m. The rooms would be back-filled with salt and sealed. Since water is the chief enemy, the salt deposits have to be ancient (have been secure from water for eons), currently dry, bedded under impermeable layers of clay or shale, and they must lie in geologically quiet regions essentially free of active faults.

In addition, the integrity of the deposits must not be violated or jeopardized by human activities, such as solution mining of salt and the deep bore holes left as the result of exploration for gas and oil. The Lyons site ultimately was abandoned in 1970 chiefly for these latter reasons (1, 19). Completely suitable sites may be difficult to find. A recent preliminary survey from the Kansas Geological Survey to the AEC (20) indicated that only one of several bedded salt regions in west and central Kansas seemed good enough to warrant further consideration. In fact, there may be very few suitable sites in the U.S. While bedded salt deposits are extensive, those that are at least 70 m thick and located within 700 m of the surface occur at only few locations: most extensively in Kansas, two smaller areas in Michigan, and one small area in New York south of Lake Ontario (1). To these should be added, however, salt-potash deposits in southern New Mexico. Recent AEC studies suggest, tentatively at least, that these deposits are also suitable. The salt domes of the Gulf area are considered unsuitable because of their geological history of migration.

Salt has desirable characteristics: It will undergo plastic deformation from modest overburden pressures and is thus self-sealing even at depths of 300 m; it is a better heat conductor than rock. Rather detailed calculations suggested that heat from radioactive decay would not have caused stresses sufficient to damage the overlying strata at the Lyons site. If valid, these calculations suggest that the entire output of high level waste in the U.S. through 2000 could be accommodated in about 1000 acres of bedded salt. The cost has been estimated to be about 0.05 mills/kw-hr for disposal of solidified waste 10 years old.

The method seems quite promising for fission products, but not for transuranic elements. The depths proposed —

of the order of 300 m — seem rather shallow to insure security for millions of years. Stability over millions of years past can provide little measure of future stability in the case of rather shallow salt beds.

Similar proposals have been made for storage and/or disposal in rock formations which are dry, impervious, show evidence of long geological stability, and are certain to have not future importance as mineral resources (1, 4, 7, 16). Ancient granites and metamorphic rock of the stable continental cores, some of which have radiological ages of 1 billion years or more, seem like possible candidates. Silicate rock has an advantage over salt in that it is essentially insoluble. On the other hand, rock does not undergo plastic deformation, at least at modest depth, and so is not self-sealing. The rigidity of rock, however permits mechanical excavations to depths of about 3000 m. Costs have been placed at about 0.07mills/kw-hr for hard rock options (4).

As mentioned above, proposals to deposit liquid and slurried wastes in underground caverns have been considered by the AEC for at least the Hanford and Savannah River facilities (9, 10). In the latter case, the plan has been under study for some 10 years. A report by the NAS recommended discontinuation in 1966, but a NAS review panel concluded the plan had sufficient merit to justify construction of a shaft and tunnels. More recently, further negative opinion has been received from NAS. A major objection concerns the mobility of the water initially associated with the wastes and the possible mobility of ground water in the vicinity of the caverns.

Care must be exercised in the matter of thermal stresses on rock as the result of radiogenic heat from the wastes. In the vicinity around a source of heat in rock there will be a

region of compressive stress merging into a region of relative tensile stress and these regions will migrate as the thermal pulse slowly moves outward. A familiar analogy in physics is the billiard ball with a heat source at its center. Rock is very strong in compression but weak in tension. It seems advisable therefore that the heat loading be adjusted so that relative tensional stresses never exceed the static compression of the overburden, i.e., that net tension is never developed. If thermal fracturing of overlying rock can be obviated, the proposal to place wastes in stable rock formations seems attractive. Depending on rock characteristics, it may be possible to permit peak temperatures high enough to eventually fuse the wastes into the rock.

8. *Deep burial:*

While rock at modest pressure and temperature does not deform plastically, it will do so at the more severe conditions encountered at great depth (6). The geothermal temperature gradient is about 30°C/km in the upper lithosphere. At 17 km, the temperature is of the order of 500°C at a pressure of about 5 k bar. Under these conditions, slow plastic deformation into a cavity can occur. If it were possible to drill very deep holes into the stable silicate core of the continent, then ceramic cylinders of waste could be emplaced in a verticle array into a region where self-sealing and permanent entrainment would occur. The axial geometry also would be a favorable one for the dissipation of radiogenic heat. The plan is not now feasible and, in any case, probably would be expensive. If electrically heated, rock melting drills were used, we estimate a cost of perhaps $20 million per hole. Assuming a 2 km depth of cylinders, each hole could accommodate perhaps 500 cylinders, each with diameter about 25 cm and length of 4 m. Each 1 G w(e) plant will produce waste equivalent to about 8 cylinders per year (~ 5 metric tons of waste products).

Thus, one hole should prove adequate on average for the operational lifetime of each reactor. By the year 2000, about 16 holes/year will be needed to hold the waste then produced. The cost of boring alone would be about 0.05 mills/kw-hr.

One advantage with the method is that such long retention is assured that transuranic elements may no longer represent a serious problem.

9. Injection of wastes in liquid form into wells:

It is a rather common industrial practice to dispose of various kinds of liquid wastes by pumping them via an encased well into porous rock formations such as sandstone or limestone. For example, U.S. Steel Corp. injects acid waste from steel-treating into a 1400 m well at Gary, Indiana, at a rate some 6.5 million gallons per month (5). In general, care is taken to select formations in which the porous rock stratum is layered between impermeable strata such as shale. The wastes can travel considerable distances laterally and examples are known in which apparently impermeable capping strata have either leaked or fractured as the result of hydrostatic effects.

In the case of limited resevoir capacity, low permeability, or viscous liquids, it is common practice to inject liquids under high pressure in order to fracture the rock, thereby increasing flow rate or capacity. This process is called "hydrofracturing." The behavior of such wells is often unpredictable, and surface contamination can occur, as was the case in a spectacular fashion in 1968 at the Hammerhill Paper Co. in Erie, Pa. There is also evidence, from the 4000 m well at the Army's Rocky Mountain Arsenal, Denver, that high pressure injections can trigger numerous minor earth tremors.

The experience with underground disposal of liquid wastes suggests that these methods would not represent an acceptable way to dispose of high level fission wastes.

10. Long term storage in surface structures:

Essentially two arguments exist for long term storage of solidified waste in surface vaults:

a) If only fission products are stored, then the periods involved (800 years) can be within the life expectance of man-made structures. Witness the pyramids of Eygpt;

b) Storage in surface vaults will buy time to develop satisfactory and totally safe methods of disposal. The latter argument, while reasonable, will impose an expensive step between liquid tank storage and final disposal. The first argument above is acceptable only if structures surely can be built to survive not only the ravages of time but also the impact of nuclear weapons and social change. The formidable design characteristics must be similar to those outlined above for liquid waste storages. Foremost, they must secure their contents from accidental release even in the absence of human attendance. It is also most desirable that they be impregnable to forcible entry. Even the pyramids have not fulfilled the latter criterion, and it is especially difficult to see how forcible entry could be prevented if the structures were, like the pyramids, left unattended.

If suitable structures can be built and if the transuranic elements can be eliminated from high level wastes, then long term storage in vaults offers the single advantage of retrievability. Surface vaults are clearly unsuitable in a world fraught with social and political instabilities over a scale of hundreds of years.

It is interesting that the AEC rejected years ago the idea of long term storage of solidified high level wastes in man-made vaults or mausolea. The focus has been on disposal in geological formations for 15-20 years. The idea has been resurrected recently since the salt mine at Lyons was abandoned around 1970 as a possible Federal waste depository. In May 1972 the AEC announced new plans for the interim management of solidified wastes (1). These plans call for the construction of "engineered surface facilities" (vaults) capable of storing the solidified wastes from commercial operations. These facilities are to be available for use in 1979-1980 when the first shipments of waste are ready for delivery from reprocessing plants. The facilities are to be designed to isolate the wastes safely for centuries with complete retrievability. The plan still stands at this writing, as far as we can determine. It strikes us as an expensive proposal born of desperation. It would appear that a permanent disposal plan cannot be assured by 1980.

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TABLE I

Typical yields of fission products with intermediate and long half-lives from processing one metric ton of light water reactor fuel irradiated to 33 x 10^9 watt-days (thermal) per metric ton fuel.*

Element	Half-life	Curies remaining after decay of:			
		10 years	100 years	500 years	1000 years
Ce-144/Pr-144	285 day	300	—	—	—
Ru-106/Rh-106	367 day	1100	—	—	—
Eu-155	1.8 yr.	160	—	—	—
Cs-134	2.1 yr.	8300	—	—	—
Sb-125/Te-125m	2.7 yr.	980	—	—	—
Sr-90/Y-90	28.1 yr.	1.2 x 10^5	1.32 x 10^4	0.6	—
Cs-136/Ba-137a	30 yr.	1.6 x 10^5	2.1 x 10^4	2	—
Sm-151	90 yr.	1100	520	30	0.4
Tc-99	2.1 x 10^5 yr.	15	15	15	15
Zr-93	9 x 10^5 yr.	3.7	3.7	3.7	3.7
Cs-135	2 x 10^6 yr.	1.7	1.7	1.7	1.7
Pd-107	7 x 10^6 yr.	0.013	0.013	0.013	0.013
I-129	17 x 10^6 yr.	0.025	0.025	0.025	0.025
Total Curies (approx)		300,000	35,000	53	22

*Calculated from data in refs. 1, 7, and 22. A 1000 Gw(e) plant will yield about 30 tons of fuel for reprocessing per year.

TABLE II

Typical yields of actinides with intermediate and long half-lives in the waste stream from processing one metric ton of light water reactor fuel irradiated to 33×10^9 watt-days (thermal) per metric ton fuel.*

Element	Half-life	Reprocessing 0.3 yrs.		Amount Present After Decay of: 10 yrs.		500 yrs.		10,000 yrs.		100,000 yrs.	
		g	Curie	g	Curie	g	Curie	g	Curie	g	Curie
Np-237	2.1×10^6 yr.	760	0.59	760	0.59	786	0.61	810	0.63	790	0.61
Pu-238	86 yr.	5.8	105	5.5	100	0.1	1.8	—	—	—	—
Pu-239	24,400 yr.	27.5	1.7	27.5	1.7	32	2.0	59	3.6	4.5	0.3
Pu-240	6,580 yr.	8.5	2.0	19.2	4.5	38.4	8.8	13.9	3.2	—	—
Pu-241	13.2 yr.	4	464	2.4	273	—	—	—	—	—	—
Pu-242	379,000 yr.	2	0.009	2	0.009	2	0.009	2	0.009	1.7	0.007
Am-241	462 yr.	54	189	55.6	198	29.5	103	—	—	—	—
Am-243	7,370 yr.	82	17.0	82	17.0	77	16.0	31	6.5	—	~0.001
Cm-244	17.6 yr.	30	2570	19.7	1700	—	—	—	—	—	—
Total g/metric ton feul		974		974		965		916		796	
Activities, including daughter products (approx)			200,000		10,000		900		100		50

*Calculated from data in refs. 1, 7, and 22. A 1000 Gw(e) plant will yield about 30 tons of fuel for reprocessing per year.

TABLE III

Projected waste inventories at the permanent repository from nuclear power generation.*

	By the Calendar Year		
	1980	1990	2000
Installed nuclear capacity (Gw(e))	100	420	734
Accumulated high-level waste			
Vol of waste (10^3 ft^3)	3.2	74.2	319
Thermal output (10^6 w)	1.2	24.4	94.9
Total radioactivity (10^6 curies)	329	7020	27700
Sr.90 (10^6 curies)	59.0	1310	5290
Cs-137 "	83.1	1850	7500
Pu-238 "	0.102	2.34	9.88
Pu-239 "	0.002	0.04	0.16
Pu-240 "	0.004	0.10	0.47
Am-243 "	0.15	3.54	15.3
Cm-244 "	1.58	34.1	133.3
Accumulated alpha waste			
Thermal output (10^6 w)	0.014	0.17	0.48
Total radioactivity (10^6 curies)	14.2	151	300
Total mass actinides (10^6g)	1.4	15.8	38.3
Pu-238 (10^6 curies)	0.23	2.57	6.02
Pu-239 "	0.05	0.58	1.41
Pu-240 "	0.07	0.83	2.02
Pu-241 "	13.8	146	286
Am-243 "	0.06	1.03	4.74

*From refs. 6, 7, and 8. Half the waste is assumed to have aged 5 years and half 10 years.

LEGEND TO FIGURES

Fig. 1 Thermal power from light water reactor wastes. Fuel utilization is taken to be 33×10^9 watt-days (thermal) per metric ton with recovery of U and Pu only with 99.5% efficience. Adapted from ref. 4.

Fig. 2 Relative toxicity of wastes from light water reactors. Burn up and recoveries are in Fig. 1. The relative toxicity is defined in the text and is relative to uranium ore. Adapted from ref. 4.

Fig. 3 Relative toxicity of waste actinides and their decay products for different degrees of actinide extraction. Burn up of fuel is as in Fig. 1. Top curve represents current practice (99.5% U and Pu); middle curve represents practical recoveries; lower curve represents likely limits. Adapted from ref. 4.

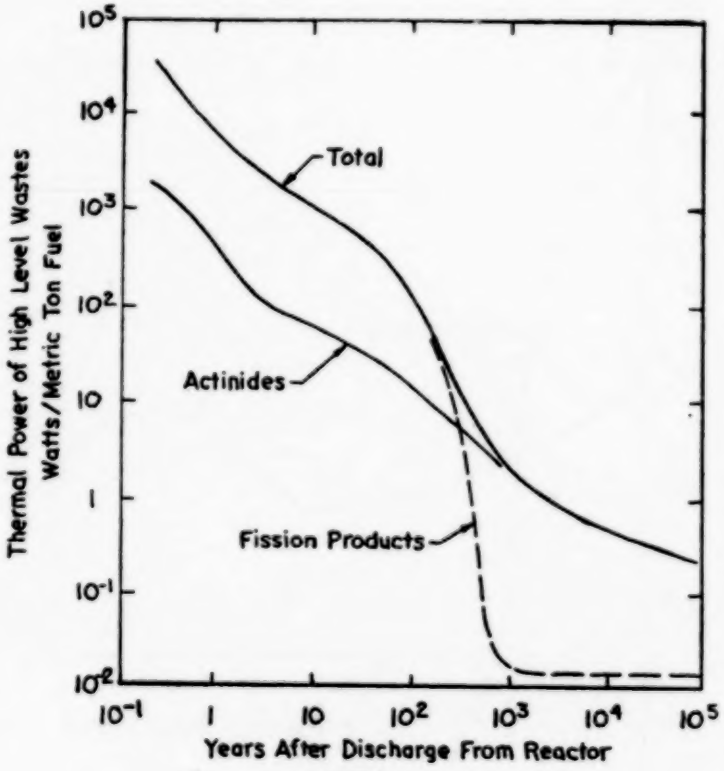
Thermal Power of High Level Wastes
Watts/Metric Ton Fuel
10^5
10^4
10^3
10^2
10
1
10^{-1}
10^{-2}
Total
Actinides
Fission Products
10^{-1}
1
10
10^2
10^3
10^4
10^5
Years After Discharge From Reactor

FIGURE 1

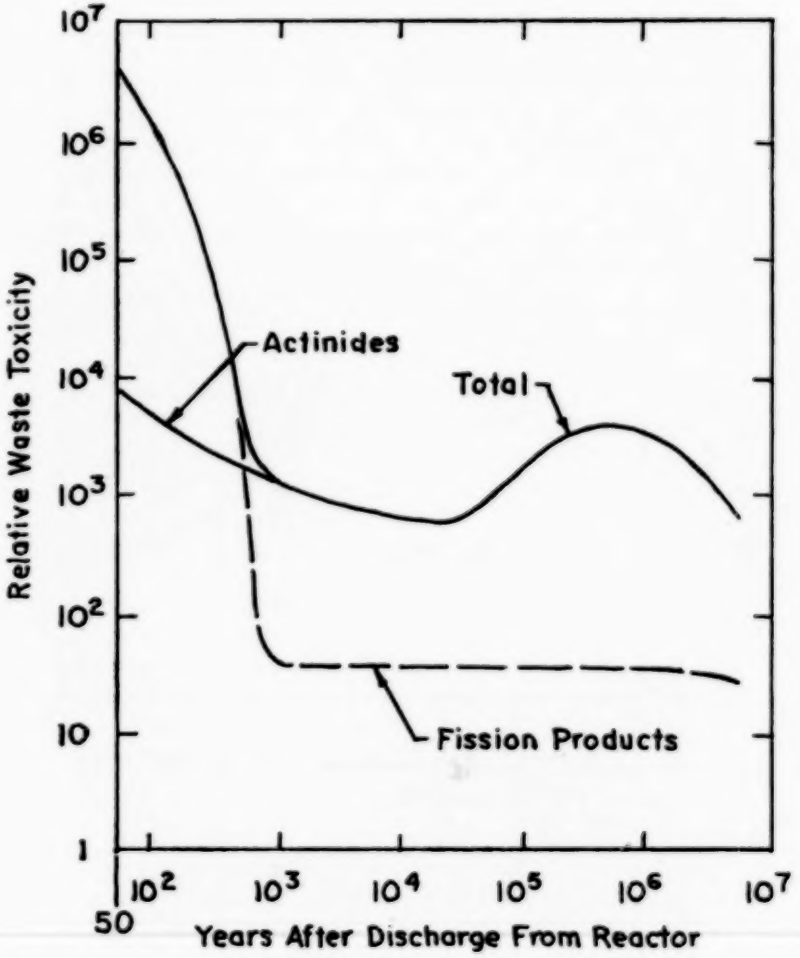
Relative Waste Toxicity
10^7
10^6
10^5
10^4
10^3
10^2
10
1
Actinides
Total
Fission Products
10^2
10^3
10^4
10^5
10^6
10^7
50
Years After Discharge From Reactor

FIGURE 2

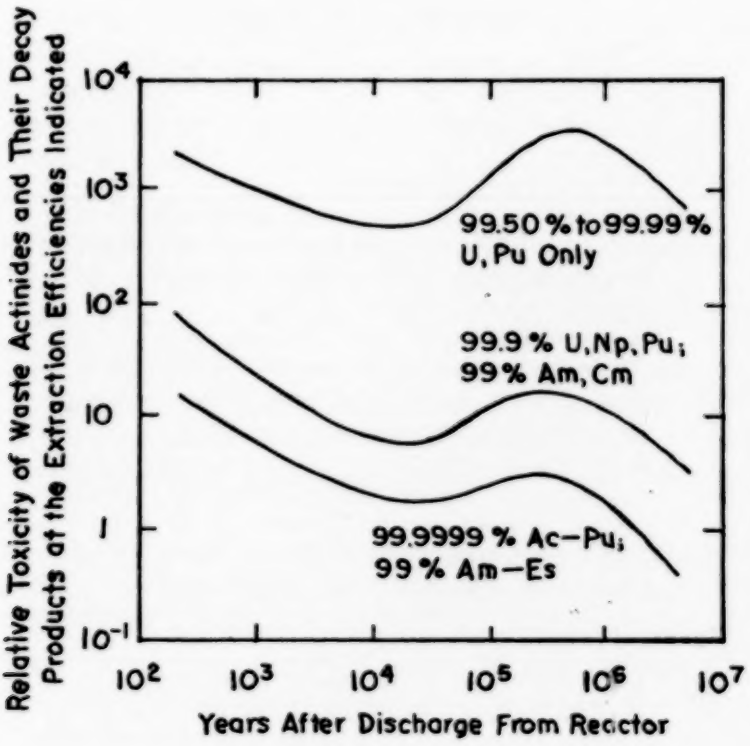
Relative Toxicity of Waste Actinides and Their Decay Products at the Extraction Efficiencies Indicated
10^4
10^3
10^2
10
1
10^{-1}
99.50 % to 99.99 % U, Pu Only
99.9 % U, Np, Pu; 99 % Am, Cm
99.9999 % Ac–Pu; 99 % Am–Es
10^2
10^3
10^4
10^5
10^6
10^7
Years After Discharge From Reactor

FIGURE 3

RADIOLOGICAL IMPACT OF WEST VALLEY REPROCESSING PLANT

SUMMARY AND RECOMMENDATIONS

I. INTRODUCTION
II. SITE
III. POPULATION DENSITY
IV. URANIUM AND PLUTONIUM RECOVERY
V. RADIOACTIVE WASTE CONTENT OF SPENT FUEL
VI. INTERCEPTOR TANKS AND LAGOONS
VII. LIQUID WASTE DISCHARGES
VIII. SEDIMENTATION IN THE LAGOONS AND CREEKS
IX. MONITORING BY THE STATE OF NEW YORK
X. MAXIMUM PERMISSIBLE WATER CONCENTRATIONS
XI. RADIOACTIVE CONTAMINATION OF CREEKS
XII. RADIOACTIVE CONTAMINATION OF FISH
XIII. NEED FOR MORE RIGOROUS STANDARDS
VIV. LEAKAGE FROM BURIAL GROUNDS
XV. RADIOACTIVE CONTAMINATION OF DEER
XVI. I-129 CONTAMINATION
XVII. ATMOSPHERIC Kr-85 CONTAMINATION
XVIII. ATMOSPHERIC TRITIUM CONTAMINATION
XIX. ATMOSPHERIC PLUTONIUM CONTAMINATION
XX. PLUTONIUM CONTAMINATION OF CREEKS
XXI. COMPOSITE MAXIMUM HUMAN RADIATION EXPOSURE
XXII. COMPOSITE MAXIMUM DEER RADIATION EXPOSURE

SUMMARY AND RECOMMENDATIONS

The reassurances from the management of Nuclear Fuels Services, Inc., that irradiation of the population around the reprocessing plant has not been excessive is a myth, when applied to wildlife. The exposure to humans, while somewhat less, is greater than necessary. In order that these exposures be reduced to more reasonable levels, it is recommended that:

(1) The more rigorous standards suggested by the National Academy of Sciences — National Research Council be implemented. Specifically, NFS should be permitted a fraction of the total permissible population exposure. Ten percent of the current limit would not be unreasonable.

(2) Rather than applying maximum permissible concentrations at the point of discharge into Cattaraugus Creek, the more stringent standards should be applied to Buttermilk Creek, as well as the lagoons.

(3) More rigorous and detailed monitoring of the wildlife within the property boundaries must be accomplished, and the more stringent standards applied to humans should be applied to all species found within these confines.

(4) The emission of I-129 from the plant must be reduced, or better, eliminated entirely. At the very least, the idoine scrubbing system must be operative during all dissolutions. Extensive study of the biological dispersion of I-129 at all trophic levels, both aquatic and terrestrial, is imperative.

(5) A krypton recovery system must be added. False economies which maintain low fuel costs at the expense of irretrievable local and worldwide radiation exposure must no longer be tolerated. As a first step in redressing this imbalance, the emission of long lived emitters such as Kr-85, in large quantities, must cease. The cost, relative to the biologic impact, would be negligible. It is a cost which should rightly be shared by all who benefit from electrical power through increased electricity rates and fuel processing tolls.

(6) Extensive human monitoring must be accomplished to determine the extent of contamination already present,

and to detect future increases before irretrievable damage occurs. The work and vocational habits of the local population and their dietary excursions must be accurately and systematically determined. A thorough accounting of the I-131, I-129, Pu-238, Pu-239, Sr-90, Cs-137, and -134, etc. content of the tissues of neighboring human populations should be accomplished through post-mortem examination, and correlated with place of residence, work, diet, etc. A program of whole-body counting of selected individuals whose exposure is likely to be excessive should be instituted. Bioassay programs to estimate tritium, Sr-90, and plutonium contamination of local populations would also be of value.

(7) The extent of local groundwater contamination by the lagoons and burial grounds should be determined and monitored.

(8) More effective burial procedures are necessary to reduce the amount of seepage from these pits.

(9) Factors promoting resolubilization and dispersion of radioactive bottom sediments should be assessed, and avoided. The cause for the amount of uranium leaving the lagoons to exceed the amount entering should be investigated and controlled.

In summary, the true cost of a nuclear-fueled electrical industry greatly exceeds the current average out-of-pocket cost of 2 mills per kwh. The true cost, in biologic terms, has yet to be determined. It will not be measured in dollars and cents.

I. INTRODUCTION

Until 1966 all nuclear fuel reprocessing was accomplished at government-owned installations such as the Hanford Works at Richland, Washington, the National Reactor

Testing Station in Idaho, and the Savannah River Georgia plant. As early as 1960, one private firm — Nuclear Fuels Services, Inc. (NFS) — concluded that recovery and reuse of plutonium and uranium from spent nuclear fuel would be a profitable endeavor. According to NFS estimates, plutonium recycle permits a 10% reduction in fuel costs. If nuclear fuel costs 2 mills per kilowat (KW) hour, then plutonium recovery and reutilization permits a credit of approximately 0.2 mills per KW hour.

Based on projected requirements for plutonium in breeder reactors, as well as plutonium recycle in current uranium based light water reactors, the decision to proceed with the first private reprocessing plant in the world was made in the early sixties. A permit was issued to NFS by the Atomic Energy Commission (AEC) for construction of the West Valley, New York plant in April, 1963, and a provional operating permit on April 19, 1966. Capital expenditure for this construction was approximately 32 million dollars.

II. SITE

NFS is located on a 3300 acre site owned by and leased from the New York State Atomic and Space Development Authority near the towns of Ashford and West Valley in Cattaraugus County, New York, 30 miles southeast of Buffalo. Both the property and the reprocessing plant, which lies 4000 feet from the nearest boundary, are isolated from the environs by exclusion fences. The installation sits amidst rolling hills reaching 500′ above sea level which are cut by two deep ravines to the north of the complex. Erdman Brook flows by the solid waste burial grounds southeast of the plant (Fig. 1) and by the reprocessing plant before emptying into Franks Creek. The latter drains into Buttermilk Creek which flows through a 100′ deep ravine north of

the plant. Buttermilk Creek, in turn, flows into Cattaraugus Creek which traverses a 300′ deep ravine approximately 3 miles north of the plant. The confluence of Buttermilk and Cattaraugus Creeks is just beyond the limit of the NFS property, while Cattaraugus Creek is entirely within the public domain.

III. POPULATION DENSITY

Population density in these environs is relatively low, despite the proximity to Buffalo. Based on 1960 census estimates, there are approximately 6000 people within a 5-mile radius of the plant, 16000 within 10 miles, and 170,000 within a 25-mile radius. Local wildlife consists of typical upstate New York lowland small game, fowl, and deer. Density of these species is not known. Aquatic biota in the discharge streams consists of an algal based food chain supporting a variety of species of fish such as shiner, horned dace, chub, white suckers, stoneroller minnows, smallmouth bass, pike, trout, etc. Maximum fishing pressure on the discharge streams occurs at Springville Dam, which lies approximately 6 miles downstream (4 miles as the crow flies) and at the mouth of Cattaraugus Creek on the shores of Lake Erie, approximately 39 miles downstream.

IV. URANIUM AND PLUTONIUM RECOVERY

NFS employs a chop, leach, Purex-solvent extraction process in recovering usable uranium and plutonium from burnt-up reactor fuel. A 1000-megawatt electric (MWe) reactor contains approximately 100 tons of uranium as fuel, one-third of which, or about 30 tons, is replaced annually. Through 1970, NFS employed 190 people who processed over 530 tons of fuel with recovery of 1300 kg of plutonium

at a cost to the utilities, in 1969, of $33,380 per metric ton of uranium (MTU). The plant ceased dissolving fuel in November, 1971, so that major renovations and expansion could be effected. An average of 100 tons were processed during each of the first 5 years of operation. NFS anticipates an annual load of 125 tons per year by 1975, and 2950 tons by 1980. Current expansion will facilitate a 3 ton per day capacity.

Spent fuel assemblies are unloaded from their shipping casks underwater, and are placed in a storage pool for further cooling. In the initial processing step, the fuel is transferred to hot cells where the end pieces are removed, and the rods mechanically chopped into small pieces and placed in baskets. In the subsequent leaching step, the fuel sections are dissolved in a vat of boiling nitric acid which leaves the undissolved fuel containers (cladding hulls) behind. The dissolved fuel is then run through several extraction cycles to separate uranium and plutonium from waste fission products, while the undissolved cladding hulls and other solid wastes are buried in the burial ground. In the final purification cycle, uranium and plutonium are further refined by additional solvent extraction and ion exchange.

The processing of a single load of fuel from a given reactor is known as a "fuel campaign". In a typical campaign in 1960, 20 tons of fuel from the Yankee plant at Rowe, Massachusetts were divided into 23 batches for dissolution between the 24th of May and the 9th of July. A given batch is processed, on the average, by 6 hours of dissolution on two consecutive days. The average campaign has required 4-6 weeks to complete. Of the 109 tons known to have been processed in 1969, 28 tons derived from the New Production Reactor at Hanford and were dissolved between February 17 and April 1, 21 tons from the same

source between April 1 and May 10, 20 tons from Rowe Yankee between May 24 and July 9, and an additional 30 tons from Hanford between August 18 and September 21. Relatively low burn-up fuel (on the order of 22,000 megawatt days per metric ton of uranium, or MWD/MTU) was processed from 1966-1968. Starting in June of 1969 higher burn-up fuels (30,000-40,000 MWD/MTU) were processed resulting in the discharge of greater amounts of radioactive waste products.

V. RADIOACTIVE WASTE CONTENT OF SPENT FUEL

Typical nuclear fuels, after 30,000 MWD/MTU burn-up and 150 day cooling contain 5 million Curies (Ci) of total beta-gamma activity per ton, including 98,000 Ci of strontium-90 (SR-90), 8400 Ci of krypton-85 (Kr-85), 375 Ci of tritium (H-3), 2.2 Ci of iodine-131 (I-131), and 30 millicuries (.03 Ci or 30 mCi) of iodine-129 (I-129). Table 1 summarizes the total waste inventory of higher burn-up fuel per ton. Fission inventory of spent fuel increases proportionally with fuel burn-up as do the waste discharges. Kr-85 yields, for example, range from 6000 Ci per ton at 20,000 MWD/MTU burn-up, and 8,000 Ci per ton at 35,000 MWD/MTU, to 9,100 Ci per ton for 40,000 MWD/MTU. I-129 content increases from 30 mCi per ton for 30,000 MWD/MTU to 40 mCi for 40,000 MWD/MTU. There are concomitant increases for tritium and other fission products. It is expected that with the increased plant capacity and processing of higher burn-up fuels that the tritium released in the NFS liquid discharges will increase from the present high of 1,200 Ci per month to as much as 20,000 Ci per month. Uranium content of spent fuel decreases from the original enriched levels of up to 3% to 0.65-0.85% at the time of reprocessing.

Almost all of the waste Kr-85 is released to the atmosphere during processing along with approximately 25% of the available tritium. Smaller amounts of xenon-133 (Xe-133) and Xe-131m and 90% of the I-129 content of the fuel are also discharged through the 60m stack. Most of the waste fission and activation products remain in liquid form at the end of reprocessing.

Higher level liquid wastes are reconcentrated and stored in multiple walled underground storage tanks set within steel saucers and supplemented by emergency stand-by tanks. About 600,000 gallons of high level wastes have been accumulated to date. NFS estimates that off-site shipment of these 600,000 gallons, for permanent storage, would cost a prohibitive $17,000,000. Consequently a high level liquid waste solidification capacity is included among the current expansion plans. Permanent long-term storage of the solidified high level wastes will be at a Federal repository, whenever one is established. In the meantime, these wastes will remain at NFS in either a liquid or solid form. Section 3 of this report deals further with the waste disposal problem.

VI. INTERCEPTOR TANKS AND LAGOONS

The low level liquid wastes from evaporator condensates, plant floor drains, and laundry and decontamination operations are discharged into two 22,000 gallon interceptor tanks. The plant license specifies (spec. 4.2.1 of license CSF-1) that in any calendar quarter no more than 48 Ci of unidentified alpha and beta activity (including tritium and I-131) shall be released from the interceptor tanks, and that the concentration of these wastes shall not exceed 5,000,000 pico-curies/liter. If the waste concentration in the interceptors exceeds these limits, the wastes are either diluted further or reprocessed prior to discharge to a series

of three unlined lagoons excavated from the ground near the interceptor tanks. These lagoons provide a reservoir of approximately 5 million gallons, enough for 100 days operation. It is estimated that a plant utilizing the Purex process produces between 10,000-100,000 gallons per ton of fuel. Lagoon-1 (300,000 gallon capacity) overflows to lagoon-2 (2,300,000 gallons), which in turn is discharged to lagoon-3 (2,500,000 gallons). The three lagoons, on the average, provide a one-month hold-up for the low level liquid wastes during which varying amounts of radioactivity settle to the lagoon bottoms. Finally, lagoon-3 is discharged to Erdman's Brook through a monitored valve system at a rate dependent upon the flow in Cattaraugus Creek. Typical discharge rates during the 1969 campaigns were 11.5-75 gallons per minute (up to 108,000 gallons per 24 hours at continuous sustained discharge).

The NFS license stipulates (spec. 4.2.2) that "activity released to Cattaraugus Creek from all sources on the site shall not at any time result in a concentration, as measured in the monitoring station in Cattaraugus Creek, which exceeds twice the concentrations specified in Title 10, CFR part 20; provided, however, that in any 365 consecutive days, the average concentration of radioactivity in Cattaraugus Creek shall not exceed that specified in Title 10, CFR part 20". Since both Erdman's Brook and Buttermilk Creek remain within the confines of the NFS restricted area, the AEC sets no limits on the amount of radioactivity in these waters. Concentration limits apply after dilution in Cattaraugus Creek.

VII. LIQUID WASTE DISCHARGES

Table II summarizes the total tritium, gross alpha, gross beta (less tritium), Sr-90, and I-129 discharged to Cattaraugus Creek in the first 4 years of NFS's operations. The

increased quantities in each category are a reflection not so much of increased volumes of fuel processed as of the processing of higher burn-up fuels. Assuming that 100 tons of fuel contain 37,500 Ci of tritium, and that 65% or approximately 25,000 Ci should be available for discharge to surface waters during reprocessing, the discrepancy between the maximum 5,980 Ci discharged to Cattaraugus Creek in 1969 is attributed to tritium leakage during reactor operations and discharge at the reactor site, before the fuel reaches NFS.

During the February-September campaigns in 1969, a total of 109 tons of fuel were processed, with tritium accounting for 13 times more activity in the lagoons and 33 times more in the Creek than any other single nuclide. The relatively greater tritium concentration in the Creek as compared to the lagoons is accomplished by sedimentation of nuclides such as Sr-90, Cs, Co-60, and Ru-106 in the lagoons.

VIII. SEDIMENTATION IN THE LAGOONS AND CREEKS

Approximately one-half of the gross beta (excluding tritium) and two-thirds of the alpha activity is retained in the lagoons. Greater than 90% of the Ce-144, Pm-147, and Zr-95 is deposited in the lagoons while 70-75% of the cesium isotopes, 59% of the Co-60, 39% of the Ru-106, and 7% of the Sr-90 are retained. Among the alpha emitters, sedimentation removes more than 90% of the plutonium (Pu) discharged from the interceptors. However, U-232, -234, and -238, which account for only 2½% of the activity in the interceptors, are present in 8.5 times greater concentration at the point of discharge from lagoon-3 indicating that uranium previously deposited in the lagoons is redissolved and discharged to Cattaraugus Creek. Most of the Ru-106, Sr-90, Co-60, and U are present in a soluble form in the

lagoons accounting for their relatively greater concentration at the point of discharge into Erdman's Brook. Those nuclides which are deposited in the lagoons are largely in an insoluble form, excepting the cesium isotopes which may be either soluble or insoluble.

Tritium, Ru-106, and Sr-90 constituted the principal nuclides in both Buttermilk and Cattaraugus Creeks during these campaigns. Lesser amounts of Cs-134, Co-60, U-232, -234, and -238 are also found in the Creeks. During these 7 months of 1969 a total of 1700 Ci of tritium, 15 Ci of Ru-106, 8.3 Ci of Sr-90, 8 Ci of Cs-137, 2 Ci of Cs-134, 0.16 Ci of Ce-134, 0.2 Ci of Co-60, 0.59 Ci of Sb-125, etc. were discharged from lagoon-3 to Erdman's Brook. Among the alpha emitters, a total of 1.8 mCi of Pu and 32 mCi of U were released.

Greater than 90% of the Cs-137 activity was removed from the water by deposition in passage from lagoon-3 to Cattaraugus Creek. Erdman's Brook and Franks Creek also retained 66% of the Co-60, 72% of the Sr-90, 31% of the Sb-125, and 26% of the Ru-106. Deposition within the property boundaries, of the Sr-90 at least, was quite variable and pH dependent. In November, when the streams were neutral, 10% of the Sr-90 was removed, whereas in June 75% of the Sr-90 was deposited at a Ph of 11. Other parameters affecting deposition were not investigated, nor is much known about what factors promote dissolution of previously deposited activity.

IX. MONITORING BY THE STATE OF NEW YORK

The New York State Department of Environmental Conservation instituted a radiation surveillance program around NFS soon after startup. Its data are usually expressed as average, minimum and maximum concentrations

measured at several points along Buttermilk and Cattaraugus Creeks. Table III summarizes the maximum values observed in Buttermilk Creek at Thomas Corner Road and in Cattaraugus Creek at Springville Dam (6 miles from lagoon-3 and 2 miles from the confluence of Buttermilk and Cattaraugus Creeks) from 1966-1972. Maximum values are recorded in Table III since radiation protection standards are designed to provide a health margin of safety above and beyond the highest observed levels. The 1966 Cs-137 level represents a pre-operational value.

X. MAXIMUM PERMISSIBLE WATER CONCENTRATIONS

The maximum permissible concentrations allowed in water by the State of New York are indicated on the following page (and in parentheses in Table III) in picocuries per liter (pCi/l). One piocurie equals .000000000001 Ci, or one-trillionth of a Ci.

Isotope	MPC_W (pCi/l)
TRITIUM	3,000,000
Sr-90	300
Cs-137	20,000
Cs-134	9,000
Co-60	50,000
Ru-106	10,000
I-129	60
Pu-238	5,000
Pu-239	5,000
U-234	30,000
U-235	30,000

These concentrations correspond to maximum permissible levels established by the Federal Government in 10 CFR part 20. Ingestion of a given amount of water or food per

year, containing these maximum concentrations of each isotope, if it alone is present, would result in the maximum permissible radiation doses of 500 millirems per year to the whole body (by tritium and cesium), 500 millirems per year to bone (by Sr-90, Pu-238, and Pu-239), and 500 millirems per year to the stomach and intestines by Co-60 and Ru-106. The maximum permissible thyroid dose of 1500 millirems per year would be achieved by drinking average amounts of water containing 60 pCi of I-129 per liter every day of the year. It should be noted that all such limits are based on standard adult parameters, and assume that only a single isotope is present. If, for example, the Cs-137 level in water results in a whole body exposure of 125 millirems per year, and the Cs-134 another 125 millirems, then the maximum permissible level of tritium would have to be reduced by one-half. Children tend to accumulate some of the isotopes more avidly than adults. The whole body dose to an infant ingesting Cs-137 is almost twice that to an adult consuming the same amount of cesium. Not all of the currently accepted standards fully account for such variations.

XI. RADIOACTIVE CONTAMINATION OF CREEKS

It is clear that from start-up in 1966 through 1970 there was an increase in the levels of all the isotopes in both Buttermilk and Cattaraugus Creeks. It should be emphasized that although the maximum levels of Sr-90 have often exceeded the maximum permissible concentration (300 pCi/l) in Buttermilk Creek, in the view of the AEC the limits were not exceeded since Buttermilk Creek is within the NFS restricted area which is exempted from the 10 CFR part 20 regulations. The standards are not applied until Buttermilk Creek empties into Cattaraugus Creek beyond the NFS boundary. Unfortunately, the wildlife in the area are unaware of this regulation.

It has often been said by those responsible for the plant that the levels in Cattaraugus Creek "have not exceeded 20% of the maximum allowable concentrations" (see p. 1217 of the 1971 Joint Committee on Atomic Energy Hearings, Part III). What is not said is that the statement is only true when the average annual values for single nuclides are applied to their average annual limits. As a matter of fact, the maximum Sr-90 values in Buttermilk Creek would have consistently exceeded the average annual limits from 1968 until 1971 had the limits been applied. What is also apparent, from the maximum concentrations in Cattaraugus Creek (Table III) is that on one occasion in 1970 the Sr-90 level reached as high as 97% of the average limit. I-129 and Pu are also present, and increased markedly from 1969 to 1970. The State of New York noted a significant rise in Sr-90 concentrations in both creeks in the last 3 months of 1969. As stated in the 1970 annual report from the Department of Environmental Conservation, "the amounts of radioactivity detected in water and fish remained at levels which confirmed the need to install liquid waste treatment facilities to hold discharges as low as practicable." This comment followed an admonition, in the 1969 report, that the "concentration of radioactivity . . . particularly Sr-90, from the Creek systems below the discharge at the fuels reprocessing plant, remain at levels that indicate that corrective action should be taken in order to hold liquid waste discharges to as low levels as practicable." Corrective action was finally initiated by the AEC at the request of the State of New York. A new low level waste treatment plant became operative on May 23, 1971. Additional filtration, sedimentation, and ion exchange processes, with burial of the contaminated waste sludge and spent resins in the on-site burial ground, resulted in the lower levels of Sr-90 and cesium relative to earlier years. The increase in tritium, which is not removed by any existing

waste treatment process, indicates that without the new facilities, the levels of Sr-90 and Cs would also have increased in 1971. Ru-106 levels were not particularly reduced. Consistently low levels were observed in 1972 since almost no fuel was processed during the year.

Prior to 1952, the deposition of naturally occurring tritium in the atmosphere produced by cosmic ray interactions produced a natural tritium concentration of 6-35 pCi/l in surface waters. Atmospheric, and consequentially, surface water concentrations increased markedly during the period of active nuclear weapons testing. In order to monitor these levels, the Bureau of Radiologic Health has maintained 10 stations around the U.S. which have routinely analyzed tritium contamination for many years. From 1964-1966 these levels ranged from 2000-20,000 pCi/l. The maximum level of 1,480,630 in Buttermilk Creek in 1969 is far higher than values observed elsewhere in the U.S., including rivers downstream from nuclear installations. The high "normal" value of 20,000 pCi/l in the surface waters of the U.S. corresponds to a whole body dose of 1.14 millirems per year assuming ingestion of 440 liters of water per year. Although humans are not known to use Cattaraugus Creek for drinking water, an animal drinking Cattaraugus Creek water at the maximum observed tritium level (184,510 pCi/l at Springville Dam) would receive 10 millirems whole body irradiation per year. The average tritium content of Cattaraugus Creek at Springville Dam increased from 19,328 pCi/l in 1970 to 30,994 in 1971 and may be anticipated to increase steadily in the future. While the tritium contamination of drinking water is not routinely monitored throughout the State of New York, several community water supplies around NFS have been analyzed in recent years. There has been no detectable tritium in this water to date (minimal detectable concentration is 5000

pCi/l). No monitoring wells exist around the plant to determine the extent of contamination of groundwater, if any. A surface monitoring site, upstream from NFS, has revealed seepage from the burial grounds, however. Tritium concentrations here reached a maximum level of 426,400 pCi/l in 1971.

Considering the large quantities of tritium released, it is only a matter of time until detectable contamination of groundwater occurs. It is imperative that the likelihood and extent of such contamination be determined. Such information could modify current tritium release procedures if unsuspected hazards are found. NFS is quite aware of these problems. However, at the present time, it is not technically possible to reduce the tritium output. A team from Oak Ridge National Laboratories conducted studies in May and July of 1971 to evaluate the feasibility of tritium disposal into a 7000′ deep well on the NFS site. While there were no releases to the atmosphere from test injections into this well, the results of the underground portion of the tests have not been published. It is unknown whether the underlying strata are suitable for such disposal. Since the amounts of tritium to be released in the future will increase markedly, it is imperative that alternative methods be developed.

Maximum plutonium contamination in the Creeks in 1971 is indicated below:

	Pu-238 (pCi/1)	Pu-238 (pCi/1)
Buttermilk Creek	1.80	0.78
Cattaraugus Creek	0.016	0.014

XII. RADIOACTIVE CONTAMINATION OF FISH

Table IV summarizes the maximum levels of Sr-90, Cs-137, Cs-134, Co-60, and Ru-106 in fish taken from Buttermilk and Cattaraugus Creeks between 1964 and 1971. Prior

to operation of NFS, the majority of nuclides were undetectable. Prior to 1970, whole fish were analyzed (i.e. fish bone and flesh were not separated). Most of the Sr-90 concentrates in bone so that the pre-1970 values are not an accurate estimate of the Sr-90 concentrations in the eatable portions of the fish. The maximum Sr-90 level of 1400 pCi/kg in 1969 compared with the 1970 maximum of 1679 pCi/kg represents a much greater increase than is apparent from the numbers alone. The bone level of Sr-90 in the maximum 1970 sample was 10,491 pCi/kg, which, compared to the 1969 level of 1400 pCi/kg, indicates a marked increase.

In general, increases in all the nuclides in fish occurred between 1966 and 1970. Bottom feeders such as shiner, dart, dace, and sucker generally mannifest higher levels than do game fish such as trout, bass, and pike which feed nearer the surface. Unlike Sr-90, cesium, cobalt, and ruthenium concentrate largely in the fleshy parts so that whole fish levels are not likely to differ significantly from the 1970 and 1971 values. It is unclear why Ru-106 levels in fish declined so precipitiously in 1971 while the maximum Creek concentrations remained relatively constant.

Unlike the regulatory authorities of some countries, the U.S. government has not seen fit to apply radioactivity standards to fish and other comestible wildlife. However, it is not difficult to estimate the amount of radiation one would receive if he consumed water, fish, deer, or other foodstuffs containing radioisotopes. In the case of Sr-90, the isotope would concentrate mainly in human bone, and the significant radiation dose would be to bone. Cesium would distribute primarily in human muscle, and the dose would be to the whole body. Ruthenium and cobalt would not be well absorbed from the stomach or intestines, so that the dose would be to the lining of the gut. Tritium dis-

tributes with the body water and produces whole body exposure. Since most of the isotopes have long physical half-lives, the individual ingesting the material would not receive the entire radiation dose immediately. The cesium isotopes, Ru-106 and Co-60 remain in the body a relatively short time (biological half-lives of less than 100 days) so that almost all of the radiation is delivered within the first year after ingestion. Sr-90, on the other hand, becomes more or less permanently bound to bone, so that only 7% of the dose from a given ingestion is delivered during the first year. One must therefore express the radiation dose as the 50 year dose commitment for Sr-90. In the case of the non-strontium isotopes discussed previously, almost all of the radiation is received within the first year so that the dose commitment may be thought of as the annual dose. If an individual ingests radioactivity on a continuous basis, as do those around NFS, the annual dose can be calculated as a series of individual ingestions. If, for example, a person drinks water, every day, containing a certain amount of Sr-90 (in pCi/l), one calculates the total pCi ingested per year, year by year, by multiplying the water concentration (in pCi/l of water) times the number of liters consumed over the entire year (440 liters on the average). By multiplying this value by the appropriate conversion factor in Table V, the 50 year dose commitment to bone from Sr-90 for that year or that ingestion can be calculated (in millirems per 50 years). If the concentration in meat or fish is known (in pCi/kg), the 50 year dose commitment for any quantity of that material is also readily obtainable. The Bureau of Radiologic Health estimates that a "typical" individual in the vicinity of NFS consumed 5.5 kg (1 kg = 2.2 lbs.) of local fish and 2 kg of local deer meat per year, while the hypothetical "maximum" individual consumes 50 kg of local deer meat and 40 kg of local fish per year. If, for example, one ate 1 kg of fish containing 5,400 pCi Sr-90

per kg of flesh (the maximum value in Buttermilk Creek trout in 1970), the total 50 year dose commitment to bone from that one meal would be $5,400 \times 8.4 \times 10^{-3} = 45.4$ millirems. Approximately 7% of this dose or 3.2 millirems would be received in the first year. If, over the course of the year, such an individual consumed 10 kg of such fish, the dose commitment would be 454 millirems for that year.

Since measurements of concentrations in fish are difficult and time consuming, it is useful to estimate what concentration a fish living in a given body of water is likely to have. In other words, by calculating the maximum amount that a given fish species has been observed to concentrate an isotope from the surrounding water, it becomes possible to estimate the dose received by eating fish taken from that water, knowing only the concentration of the isotope in the water and the amount of fish consumed. It is apparent from Table III that the concentrations of the various isotopes in Cattaraugus Creek are considerably less than in Buttermilk Creek, differing, on the average, by a factor of ten (except for plutonium). However, the concentration in fish flesh, relative to the concentration in the surrounding water (the so-called concentration factor) does not differ markedly between the two Creeks. According to measurements made by the State of New York, the concentration of Sr-90 in the flesh of bottom feeders in Cattaraugus Creek may exceed the concentration in the surrounding water by 22 times. Maximum concentration factors have also been determined for Cs-137, Cs-134, Ru-106, and Co-60 by dividing the maximum fish levels by the maximum water concentrations for that year. Concentration factors derived by this method are quite conservative compared to values reported in the literature. Concentration factors as high as 22,000 have been reported for cesium in freshwater fish, 90 for Sr-90, and 3,450 for Co-60. Tritium is not concen-

trated by fish, but occurs at approximately the same level in fish as in the surrounding water. The estimated 50 year dose commitment after consumption of a given number of pounds of fish, knowing only the isotope concentration in the water, can be obtained simply by reference to Table VI. Estimated doses could be much higher if the estimated concentration factors, derived from relatively few fish samples, are lower than the actual maximum values as suggested by the literature. With 2,009 pCi of Sr-90 per liter of Buttermilk Creek (1970) and a maximum concentrating factor of 22, the 50 year dose commitment to the bone of a person eating 10 kg (22 lbs) of fish from these waters would be $2008 \times 10 \times 22 \times 8.4 \times 10^{-3} = 3{,}710$ millirems, or $3{,}710 \times 7\% = 260$ millirems per year.

Granted that a worst possible case illustration has been used, it is based on observed concentrating abilities of local fish and observed isotope levels in the discharge creeks. Without firm evidence that edible fish do not migrate from Buttermilk Creek, and realizing that actual maximum concentrating factors may be higher than those given here, it is not unreasonable to ask why standards have not been applied to Buttermilk Creek. The highest recorded value of Sr-90 in the flesh of bottom feeders taken from Buttermilk Creek is 14,456 pCi/kg. Ingestion of one kg of such fish would result in a 50 year dose commitment to bone of 121.4 millirems.

XIII. NEED FOR MORE RIGOROUS STANDARDS

Although these may be extreme instances, the paucity of information on the actual quantity of fish consumed in the region, the migration patterns of fish, and their isotopic concentration make more restrictive standards mandatory. While the new low level waste treatment facility did result in lower levels in the Creeks and fish in 1974, the fact that

the plant will be processing higher burn-up fuel in greater quantities in the future will no doubt reverse this downtrend. It is imperative that more restrictive controls be applied, and that the frequency with which these worst possible cases are actually occurring be accurately determined. Bland reassurances that "our record of performance relative to protection of the public and of our own employees has been successful when measured against permissible standards as authorized in our AEC facility license" and that "On an annual basis, our liquid effluents have ranged from 6-18% of Federal regulations with a typical value of 10%", are numerical half-truths obscuring the degree of contamination that has already occurred. What is important is not only what comes out, or how much relative to such and such a standard, but where it goes and what it does once it gets out. Without independent monitoring by the State of New York, the magnitude of the problem would still be obfuscated. As indicated later in the testimony of Mr. Runion before the Joint Congressional Committee in 1970 (see above), NFS has been nowhere near as successful in controlling omissions as originally anticipated. "We try to maintain as a target in our original design something on the order of less than 5% of the limit. The operating characteristics of the plant, the practical problems that we ran into, have all pushed us above these limits. Fortunately, the plant has not yet operated at a level above 50% of its capacity." And yet, NFS is undergoing a major expansion.

If, as recently recommended by the National Academy of Sciences-National Research Council, the nuclear industry were apportioned only a fraction (say 1/20 – 1/10) of the present maximum permissible population exposures, with the remainder divided up among other sources of radiation exposure, then NFS would be required to limit its emissions

to a small percentage of the 1966-1971 levels. If, for example, the plant could not maintain a Sr-90 level of less than 15-30 pCi of Sr-90 per liter of Buttermilk Creek, it would be in excess of the limit. It is interesting to note that the more modern, Morris, Illinois, and Barnwell, South Carolina reprocessing plants have been designed to emit no liquid effluents. It is not unreasonable to ask why such performance should not be expected of NFS.

XIV. LEAKAGE FROM BURIAL GROUNDS

The low cesium concentrations in the Creeks in 1966 prior to start-up reflect overflow or seepage from the solid waste burial trenches southeast of the plant. These pits are excavated from the ground and filled with undissolved fuel cladding and other low specific activity solid wastes. The solid detritus from 1970 operations filled a single 300,000 cubic foot trench (trench #8) with 150,000 cubic feet of waste containing 40,000 Ci of total beta-gamma activity. The trenches are not covered until full, so that the radioactive materials are often soaked by snow and rain. During 1970, approximately 1,000,000 gallons of water were pumped from trench #8. NFS estimates that this water contained only 40 mCi of activity, i.e. only 1/1,000,000 of the total activity in the trench. However, Erdman's Brook upstream from the processing plant and downstream from the burial site contains significant amounts of activity leached from the burial site, which in turn contributes to the isotopic inventory of Buttermilk Creek. It is estimated that 14% of the cesium in Buttermilk Creek and 20% of the ruthenium derive from the burial site. In recent years, a monitoring station on a small brook northeast of the burial site has also demonstrated some activity indicating either surface drainage or underground seepage in this direction. The isotopic inventory of the burial site is not publicly

available, if it is known, and the rate of migration from the burial site has not been determined. There are no monitoring wells in the vicinity, and the extent of groundwater contamination, if any, and the likelihood of such contamination, are unknown.

XV. RADIOACTIVE CONTAMINATION OF DEER

Contamination of local deer is attributed primarily to deer drinking from the storage lagoons and Buttermilk Creek. Maximum levels of strontium and cesium in deer meat in 1970 and 1971 declined compared to the first three years of operation (see Table VII). Cobalt levels remained relatively constant while tritium content increased. The 50 year dose commitment to persons consuming deer meat containing the maximum levels in 1971 are relatively low. Such meat would produce a 50 year dose commitment to bone of 0.04 millirems per pound of meat, and 0.05 millirems whole body from the Cs-137 and Cs-134. Sr-90 levels in 1968 would have resulted in a 50 year bone dose commitment of up to 2.2 millirems per pound. Whole body irradiation from the maximum tritium content in 1969 would have been 0.09 millirems per pound to the person consuming such meat.

Although no standards exist in this country protecting the wildlife around nuclear installations, observed levels in deer, were they observed in man, would be cause for concern. Assuming a deer weighs 220 pounds (100 kg), and that the tritium content of the entire body in 1971 was the same as that of the meat, the deer could contain up to 693,550 x 100 pCi of tritium. The whole body irradiation to such a deer would be 8.8 millirems. Assuming 30 kg of muscle, the total 1971 cesium (137) content would be 32,840 pCi and the whole body dose 1.9 millirems. At the maximum 1967 Cs-137 level of 66,956 pCi/kg, the whole body dose would have been 120 millirems. It is interesting that

the lower levels of cesium in 1971, relative to 1969 and 1970, are still higher than the levels in Colorado mule deer at the peak of atmospheric fallout in 1963. Alarm over the ubiquitousness of this radioactive contamination of all life forms set the stage for the successful negotiation of the nuclear weapons test ban treaty in 1963. Since that time, Cs-137 levels in Colorado deer have declined to an average of 64 pCi/kg, or twenty times less than in deer around NFS in 1971.

XVI. I-129 CONTAMINATION

I-129 levels in Buttermilk Creek reached a peak of 7.8 pCi/1 in 1971 and declined to 1.4 pCi/1 in the first six months of 1972. Approximately 2% of the I-129 content of spent fuel is discharged in the liquid effluent, and the balance to the atmosphere. The great majority of the vaporized I-129 can be retained on iodine absorbers. However, the plant is permitted to bypass these absorbers if the I-131 content of the fuel is low. Since much of the fuel has been stored for long periods, the I-131 content has been sufficiently low so that the scrubbers have not always been operative during dissolution. The result has been unnecessary discharge of I-129 to the atmosphere. With a half-life of 17 million years, I-129 release constitutes an irretrievable environmental degradation. Most of the I-129 released to the atmosphere is returned to the ground within 20 miles of the plant. The fate of this material once deposited on the ground is largely unknown.

According to the specific activity method, a thyroid gland containing 0.03 microCi of I-129 will receive the maximum permissible annual thyroid dose of 1.5 rems. Assuming a 30 gm thyroid in deer, the 1970 maximum thyroid I-129 concentration of 3700 pCi/gm would deliver 5.6 rems, or almost 4 times the human limit, to the deer thyroid. For-

tunately, deer thyroid is not known to be consumed by most hunters. It is unclear precisely how these deer obtain such quantities of I-129. If a deer took all of its drinking water from Buttermilk Creek with a maximum I-129 concentration of 7.8 pCi/1 the total thyroid I-129 content would only have been on the order of 25 pCi/gm, substantially less than the observed maximum. It is unknown what other sources of I-129 are available to deer and small game in the NFS area. One likely possibility is that I-129 is more extensively distributed in the local food chain than realized. A single seaweed specimen taken from Cattaraugus Creek in 1967 contained 0.81 microCi of I-129 per gram of total iodine, presumably derived from the iodine in the creek system. It is not unreasonable to assume that certain biota in the woods around NFS are retaining and concentrating I-129 from the atmosphere in a similar fashion. Further study is necessary to determine the extent of such contamination.

Nothing is known about the human consumption of I-129 or the concentration in thyroid glands of humans in this area. While the concentration of Cattaraugus Creek in 1971 was approximately 0.6 pCi/1 I-129 in the local water supplies have not been determined. A human drinking 2.2 liters of Cattaraugus Creek water per day would accumulate approximately .00016 microCi of I-129 after one year and receive a thyroid dose of 5 millirems per year.

The State of New York has maintained a milk surveillance network for several years, but has only been able to detect I-129 levels of less than 16 pCi/1 for the past two years. In 1971, the last year for which data are available, the maximum milk I-129 concentration was 1.2 pCi/1 at a farm 1.7 miles east of the plant. Were 1 liter of such milk consumed every day, the annual human thyroid dose would have been 2.7 millirems per year.

XVII. ATMOSPHERIC Kr-85 CONTAMINATION

In terms of the total curies of activity discharged through the plant stack, Kr-85 is the most important nuclide by far. During the 1969 fuel campaigns, an average of approximately 5,000 Ci of Kr-85 were released per day of dissolution, compared with 40-50 Ci of tritium per day. Twenty to 50 Ci of Kr-85 are released during the initial chopping operation, and the remainder during the dissolution step. Kr-85 discharges from the stack reach a maximum around 10 minutes after the start of dissolution, then decrease toward background over the next 3-4 hours. During two days of processing in 1969 (June 12 and 14), the peak atmospheric Kr-85 at the property boundary was 9.3×10^{-6} microCi/cc (or 9,300 pCi/1). The average ranged from 4.8×10^{-7} to 6.4×10^{-8} microCi/cc. The average fence limit is 1×10^{-7} microCi/cc or 100 pCi/1. Actual measurements indicate that by the time Kr-85 reaches the fence, 1500 meters from the stack, it has been diluted by about 42,000 times.

Were the peak of 9300 pCi/1 (achieved during dissolution) to prevail at the boundary throughout the year, the whole body dose in the path of the plume would be 19.3 rem. It is estimated that a 3 hour maximum of this order of magnitude corresponds to a 24 hour average concentration at the fence of 680 pCi/1 which would produce a whole body dose of 1.46 rems per year if the plant dissolved every day. Table VIII summarizes the maximum Kr-85 levels at various monitoring sites maintained by the State of New York in Ashford. Kr-85 levels in Albany, several hundred miles to the east, ranged from .035-.088 pCi/1. The maximum value at Ashford in 1969 was 7.8 pCi/1 which would result in an annual whole body dose of 16.2 millirems if sustained for the entire year. Continuous observations have not been made and the actual exposures to the surrounding population are unknown.

Since a variety of techniques are available for removing Kr-85 from the gaseous effluent, NFS commissioned the Blaw-Know Co. in 1971 to determine the cost of an improved krypton recovery system. Whether the decision has been made to spend the money that such a system would require is unknown. It should be noted that the Environmental Protection Agency has recently concluded that such systems should be required at nuclear power plants. Considering the quantities of higher burn-up fuel that will be processed in the future, it is anticipated that exposures to surrounding populations will increase significantly if such a system is not installed. It has been estimated that a plant processing 6 MTU of 40,000 MED/MTU per day of fuel would release 1.2 Ci of Kr-85 per second compared to an average Kr-85 release rate of .047 ci/sec currently at NFS. If NFS operates at its new capacity of three tons per day when it reopens, Kr-85 releases could increase ten times over current levels, and maximum annual whole body exposures in Ashford would be up to at least 163 millirems per year.

XVIII. ATMOSPHERIC TRITIUM CONTAMINATION

While the amount of tritium discharged to the atmosphere is small compared to the quantity of Kr-85, the radiation dose from the tritium is not inconsequential. Since most of the tritium releases from nuclear facilities are into the liquid waste streams, there has been relatively little attention paid to the atmospheric releases. However it is known that during the 1969 fuel campaigns, 0.6 Ci of tritium emanated from the stack during the processing of batch #13 on June 12 and 0.4 Ci from batch #14 of June 14.

The residual atmospheric tritium from nuclear weapons testing together with naturally occurring tritium in the

stratosphere accounts for the ambient tritium levels of 200-1000 pCi/l of moisture in air. The concentration of tritium per liter of air is 1.18×10^{-5} times the concentration of tritium per liter of moisture in air.

Stratospheric tritium remains in the atmosphere for long periods, with a mean residence time of 1-10 years, then gradually percolates to lower tropospheric levels where it is rapidly flushed out by rainfall after an average residence time of one month. For local releases, such as from the NFS stack, the downward diffusion of the plume probably results in the tritium depositing on the ground before washout by rain can occur. Approximately 72% of the tritium on the ground is returned to the atmosphere by evaporation and transpiration every year, with the balance migrating by surface runoff and underground seepage.

In a 1967 study at NFS, over 700 air samples were collected over 7 legs radiating from the stack out to a distance of 4 miles. An arbitrary value of 2,500 pCi of tritium per liter of moisture in air was chosen as the upper limit of ambient tritium. 75% of the observed values on the leg extending northwest from the stack exceeded 2,500 pCi/1, as did 20% on the northern and southern radials. The highest recorded value was 26,400 pCi/1. The tritium concentration exceeded 10,000 pCi/1 39% of the time northwest of the plant. Constant immersion, for 365 days, in air containing 2,500 pCi of tritium per liter of moisture in air would produce a dose of less than 0.1 millirems per year, while 10,000 pCi/1 would result in 0.13 millirems whole body exposure, assuming 3 hours of dissolution, 250 days per year.

Springville Dam lies along the northwest radial, approximately 4 miles from the stack and fishermen at the Dam would receive a small whole body exposure from the tritium

in the air, in addition to the atmospheric Kr-85 contribution and the radiation emanating from the radioactive sediments in the Creek bed. The maximum Cattaraugus Creek bank background, in November of 1970, was 0.132 millirem per hour.

The authors of the 1967 tritium study concluded that "it is recognized that much more work needs to be done." Such work remains to be done. Two years later, Mr. Runion, the President of NFS, testified before the JCAE that "airborne contamination has not been a problem at West Valley."

XIX. ATMOSPHERIC PLUTONIUM CONTAMINATION

In addition to significant quantities of krypton and tritium in the air, there are also measurable quantities of the isotopes of plutonium. This material, according to its discoverer and former Chairman of the AEC — Glenn Seaborg — is among the "most toxic" substances known to man. The maximum permissible air concentration (Pu-238) of 0.07 pCi/m^3 would produce a maximum permissible exposure to the lungs of 1.5 rems per year. The MPC_a for Pu-239 is 0.06 pCi/m^3. Once a person breathes plutonium laden air, a certain portion of the plutonium, determined by the particle sizes, is trapped in the lungs with a biologic half-life of 500 days. For the purposes of the following calculations, it is assumed that only 10% of the plutonium is retained in the lungs. In the opinion of some, 25% is a more reasonable figure. After a certain time, most of the lung plutonium is cleared to the lymph nodes about the lung roots where it remains more or less permanently. The maximum lung radiation is to these so-called hilar lymph nodes.

A small quantity of plutonium persists in the air from nuclear weapons tests, and is characterized by a Pu-239: Pu-238 ratio of much greater than 1, commonly 5-15. Plutonium around the West Valley plant, to be definitely attributed to plant operations, must manifest a Pu-239:Pu-238 ratio of less than 3, or must manifest much higher levels than might be expected from fallout alone. Low burn-up fuel, such as processed in the earlier campaigns, is characterized by a ratio of 1-3, whereas the higher burn-up fuels of later campaigns manifest a ratio of less than 1 (as low as 1:10).

In 1970, the first year in which the State of New York determined Pu ratios in the air of Cattaraugus County, atmospheric plutonium from NFS was clearly detectable beyond the plant confines. Maximum Pu-239 level was .00043 pCi/m^3 and Pu-238 .00014 pCi/m^3. Assuming an individual breathes 20m^3 of air per day, and that 10% of the inhaled plutonium is retained in the lungs, the total 50 year dose commitment from these levels of plutonium would be 26.6 and 41.4 millirems respectively, or a total dose of 68 millirems to the hilar nodes for the 1970 commitment alone. Even higher levels were detected in 1971 but the ratios were such that they could not be clearly attributed to West Valley operations. Plutonium levels in deer lung were first determined in 1971. Maximum Pu-238 in deer lung was 0.72 pCi/kg and Pu-239 0.03 pCi/kg. Assuming 2000 g of lung, the 50 year dose commitment to the hilar nodes of these deer would be 190 and 15.6 millirems respectively. Plutonium concentrations in hilar nodes, rather than whole lung, were not determined.

XX. PLUTONIUM CONTAMINATION OF CREEKS

Plutonium is also present in Buttermilk and Cattaraugus Creeks where the maximum concentrations were 0.78 pCi/1 of Pu-239 and 1.80 pCi/1of Pu-238 in 1971, the first year in which such measurements were reported. Ingested plutonium concentrates mainly in liver and bone in contrast to inhaled plutonium which remains in lung. Had these levels been sustained over the course of the year, and assuming that the deer drank 1000 liters of water from Buttermilk Creek at these levels, the total dose commitment to bone from Pu-239 would have been 4 millirem. Unfortunately deer sampling procedures do not include bone. Neither the Sr-90 nor the plutonium concentration in bone have been determined. Such information would be of considerable value. Plutonium levels in fish and other aquatic biota have also not been determined. It has been learned, from studies on salt water species, that marine forms may concentrate plutonium to many times the levels in the surrounding water. Sargassum, for example, has a concentration factor of up to 21,000. Concentration factors of 600-1000 have been observed in algae and up to 2500 in various zooplankton. Marine vertebrates such as tuna, bass, and tautog concentrate plutonium in bone over 500 times.

XXI. COMPOSITE MAXIMUM HUMAN RADIATION EXPOSURE

Table IX summarizes the maximum dose commitments to a hypothetical individual utilizing maximum observed concentrations in various media during the first five years of NFS operation. This individual is assumed to consume 380 liters of milk, 50 kg of deer meet, 40 kg of fish, and 730 liters of drinking water, per year, and to breath 20 m^3 of air per day, all at the maximum observed concentrations

of the various radioisotopes. It is also assumed that this individual spends 3 hours a day fishing at Springville Dam, 250 days a year, during fuel dissolution. If such an individual is thought to be too hypothetical, it should be pointed out that the maximum isotopic levels in fish were derived from maximum concentrations in fish taken from Cattaraugus Creek and the maximum Kr-85 levels from those observed in Ashford rather than those at the property boundary. Had maximum levels from Buttermilk Creek fish and the property boundary been utilized, the dose commitments would be much higher. For example, the maximum concentration of Sr-90 in the flesh of a sucker taken from Buttermilk Creek in 1970 was 14,456 pCi/kg. Had this fish migrated to Cattaraugus Creek, and been caught by a fisherman at Springville Dam, that individual would receive a 50 year dose commitment to his bone of 55 millirems for each pound of the fish that he consumed. The maximum Sr-90 level in a Buttermilk Creek trout was 5,400 pCi/kg, equivalent to a bone dose commitment of 20.6 millirems for each pound consumed. The bone of this same trout contained 320,000 pCi of Sr-90/kg. If a few fish bones were ingested along with the flesh, each gram of the fish bone would deliver a dose commitment to the fisherman of 2.7 millirems (a single teaspoon will hold 9 grams of ground bone). The maximum Sr-90 content of the bone of a Buttermilk Creek sucker in 1970 was 620,000 pCi/kg, equivalent to 5.2 millirem per gram. It would behoove the fisherman in the vicinity of NFS to filet his fish carefully.

The total bone dose commitment to the maximum individual, including Sr-90 from milk, deer and fish, would be 1,351 millirems. The dose to bone from plutonium is unknown. 7% or 94 millirems of the Sr-90 dose would be delivered in the first year. In addition to the unknown dose from the plutonium isotopes, the commitment from previous year's

Sr-90 ingestion, other bone seeking nuclides, Sr-90 in fish bones, and the bone dose from whole body irradiation would easily exceed 100 millirems, could this dose be determined accurately. If, as suggested in the National Academy of Science-National Research Council report, the emissions from nuclear facilities were limited to a fraction of the total population radiation exposure (say 10%), the predicted dose to the hypothetical maximum individual would exceed the limit.

The postulated maximum individual would accrue a whole body dose of 286.5 millirems, or greater than 50% of the current limit, from consumption of milk, deer, fish containing observed maximum levels of Cs-134 and Cs-137, and tritium, as well as from drinking tritiated water, and breathing air containing tritium and Kr-85. Had the maximum fish levels from Buttermilk Creek been utilized, those doses would have been considerably higher. Although tritium levels in the public water supplies are much lower than in the Creeks, and produce an annual dose of less than 1 millirem, should the hypothetical maximum individual chose to derive his entire drinking water supply from Cattaraugus Creek at its maximum tritium level, he would accrue an additional whole body dose of 17.5 millirems per year. It has also been assumed that this individual spent 750 hours along the banks of Cattaraugus Creek (with an average Creek background of .020 millirem per hour rather than the maximum observed level of .132 millirem per hour) and "maximum" atmospheric tritium and Kr-85 levels.

Should this hypothetical maximum individual be desirous of reducing his radiation exposure he would need to adhere to the following simple guidelines:

(1) DON'T GO NEAR THE WATER.

(2) IF YOU MUST GO NEAR THE WATER, DON'T DRINK THE WATER.

(3) IF YOU MUST FISH IN THE WATER, USE AS LONG A POLE AS POSSIBLE, AND STAND AS FAR BACK FROM THE BANK AS POSSIBLE.

(4) IF YOU CATCH FISH, DON'T EAT THEM.

(5) IF YOU MUST EAT THE FISH, FILET THEM CAREFULLY.

(6) DON'T HUNT THE DEER.

(7) IF YOU MUST HUNT THE DEER, DON'T EAT THE MEAT.

(8) IF YOU MUST EAT THE MEAT, DON'T EAT THE THYROID.

XXII. COMPOSITE MAXIMUM DEER RADIATION EXPOSURE

The maximum hypothetical deer would receive almost 300 millirems whole body per year (Table X), assuming he drank 1000 liters of Buttermilk Creek at maximum tritium levels and inhaled 20m³ of air containing Kr-85 at its "maximum" observed level in Ashford. The tritium contribution would be 8.9 millirems per year, Cs-137 120.5, Cs-134 29.6, Sr-90 136.9, and Kr-85 1.4. At the maximum observed thyroid I-129 concentration, the thyroid dose would be 5.6 rems per year which exceeds the maximum human limit of 1.5 rems by 3.7 times. The bone dose, from plutonium at maximum observed levels in Buttermilk Creek, would be approximately 1 millirem from Pu-239. The bone dose from Sr-90 ingestion at maximum Buttermilk Creek levels could be up to 16.7 rems for a total bone dose commitment of 16.8 rems per year. Assuming 7% of the Sr-90 and 2% of the plutonium dose commitment is delivered in the first year, the

annual bone dose would be approximately 1,176 millirems, or 2.8 times the maximum bone dose permitted humans. Unfortunately, deer taken from the NFS site have not been analyzed for bone Sr-90 and plutonium content.

It is apparent that the failure to include the wildlife in the radiation exposure considerations has resulted in substantial irradiation of deer and probably other denizens of the woods around NFS. Without compelling reasons to the contrary, it is illogical not to apply the same standards to wildlife as to humans. The fallacy of such an oversight should be self-explanatory, and is strongly reinforced by the excessive thyroid and bone doses calculated for local deer. Although cesium and strontium levels declined during 1970 and 1971, they can be anticipated to increase in the future. The estimated maximum exposures may well be exceeded in the future if standards are not applied to wildlife. I-129 levels will certainly increase unless stack discharges are controlled. Tritium levels, and resulting whole body exposure, will increase inexorably.

TABLE I.

Radionuclide Content of light water reactor fuel decayed 150 days.

Nuclide	Concentration (curies/metric ton)	Nuclide	Concentration (curies/metric ton)
^{3}H	692	^{131}I	2.17
^{83}Kr	11,200	^{132}I	—
^{89}Sr	96,000	^{133}Xe	—
^{90}Sr	76,600	^{134}Cs	213,000
^{90}Y	76,600	^{136}Cs	20.8
^{91}Y	159,000	^{137}Cs	106,000
^{95}Zr	276,000	^{140}Ba	430
^{95}Nb	518,000	^{140}La	495
^{99}Mo	—	^{141}Ce	56,7000
^{99m}Te	—	^{144}Ce	770,000
^{99}Te	14.2	^{143}Pr	694
^{103}Ru	89,100	^{147}Nd	51.0
^{106}Ru	410,000	^{147}Pm	99,400
^{103m}Rh	89,100	^{149}Pm	—
^{111}Ag	—	^{151}Sm	1150
^{115m}Cd	44.3	^{152}Eu	11.5
^{124}Sb	86.3	^{155}Eu	6370
^{125}Sn	20.0	^{160}Tb	300
^{125}Sb	8130	^{239}Np	17.4
^{125m}Te	3280	^{238}Pu	2810
^{127m}Te	6180	^{239}Pu	330
^{127}Te	6110	^{240}Pu	478
^{129m}Te	6690	^{241}Pu	115,000
^{129}Te	4290	^{241}Am	200
^{132}Te	—	^{242}Cm	15,000
^{129}I	0.038	^{244}Cm	2490

Source: ORNL-1451

TABLE II

Total annual liquid releases according to figures provided the JCAE by NFS in 1970

	1966 (Ci)	1967 (Ci)	1968 (Ci)	1969 (Ci)
Gross alpha	.038	.056	.139	.376
Gross beta	8.265	30.70	46.400	136.100
Tritium	289.520	4204.000	2612.000	5980.000
Sr-90		4.366	5.03	5.289
I-129		.070	.023	.184

TABLE IIIa

Maximum isotopic levels in Buttermilk Creek 1966-1970 in pCi/l (State of New York data)

	Tritium	Sr-90	Cs-137	Ru-106	I-129	Pu-238	Pu-239
1966			1				
1967			100				
1968	1,133,920	1,015	666				
1969	431,010	1,658	1,161	5,816		0.63	0.60
1970	1,185,290	2,008	972	3,917		2.40	1.90
1971	1,480,630	1,841	692	10,875	7.8	1.80	.078
1972	90,200	337	41	3,846	1.4	.23	.08

TABLE IIIb

Maximum isotopic levels in Cattaraugus Creek at Springville Dam 1966-1972 in pCi/l (State of New York data)

	Tritium	Sr-90	Cs-137	Ru-106	I-129	Pu-238	Pu-239
1966			1				
1967			10				
1968	110,430	60	20				
1969	98,600	224	86	421		0.64	1.36
1970	103,770	291	197	782		3.60	2.20
1971	184,510	117	29	481	0.6	.016	.014
1972	9,090		119				

TABLE IVa

Maximum isotopic levels in Buttermilk Creek bottom feeders 1965-1971 in pCi/kg (New York State data)

	Sr-90	Cs-137	Co-60	Cs-134	Ru-106
1965		1,685			
1966	81				
1967	15,300	27,500	340	5,750	1,750
1968	22,800	13,400	342	3,140	2,990
1969	5,668	6,032	242	689	3,611
1970	14,456	34,835		5,890	
1971		4,659		742	

TABLE IVb

Maximum isotopic levels in Cattaraugus Creek at Springville Dam in bottom feeders 1965-1971 in pCi/kg (New York State data)

	Sr-90	Cs-137	Co-60	Cs-134	Ru-106
1965		23			
1966	1,035				
1967	906	3,610	32	499	796
1968	3,080	1,330	382	1,170	155
1969	1,400	3,141	95	1,547	389
1970	1,679	3,198		534	
1971	45	1,666	23	301	

TABLE IVc

Maximum isotopic levels in Buttermilk Creek surface feeders (trout, bass, pike) 1969-1970 in pCi/kg (New York State data)

	Sr-90	Cs-137	Co-60	Cs-134	Ru-106
1969	3,577	6,210		670	
1970	5,400				

TABLE IVd

Maximum isotopic levels in Cattaraugus Creek surface feeders (trout, bass, pike) 1967-1970 in pCi/kg (New York State data)

	Sr-90	Cs-137	Co-60	Cs-134	Ru-106
1967		2,100	8	390	
1968	41	591	646		2,511
1969	272	722		268	
1970	301	2,608		453	
1971	5	315			

TABLE V

Target organ and dose per pCi of each isotope consumed (multiply concentration in media consumed in pCi/l or pCi/kg by column 4 to obtain 50 year dose commitment).

Isotope	Target organ	method of consumption	millirem/50 years per pCi of intake (conc in pCi/l of water, food or air)
Sr-90	Bone	ingestion	8.4×10^{-3}
Pu-239	Bone	"	1.2×10^{-3}
Cs-137	whole body	"	0.06×10^{-3}
Cs-134	"	"	0.08×10^{-3}
Ru-106	GI tract	"	0.195×10^{-3}
Co-60	"	"	0.04×10^{-3}
Tritium	whole body	inhalation and skin submersion in air	1.86
Kr-85	"	"	2.08
Pu-238	Hilar lymph nodes	inhalation	132
Pu-239		"	260

TABLE VI

Estimated radiation dosage from consuming x pounds of fish flesh from Buttermilk or Cattaraugus Creeks knowing only the water concentration of the isotope of interest

Isotope	Target organ	Maximum concentration factor in bottom feeders	Maximum concentration factor in surface feeders	Multiply water concentration in pCi/1 by this conversion factor number of pounds of fish consumed to obtain 50 year dose commitment for bottom feeders	Multiply water concentration in pCi/1 by this conversion factor number of pounds of fish consumed to obtain 50 year dose commitment for surface feeders
Sr-90	Bone	22	4.6	.08	.017
Cs-137	WB	54	13.2	.0015	.0036
Cs-134	WB	25.3	2.7	.00092	.000098
Ru-106	GI	3.0	25.1	.00027	.0023
Co-60	GI	95.5	161.5	.0017	.0029

TABLE VII

Maximum isotopic levels in NFS deer 1967-1971 (New York State data) in pCi/kg

	Sr-90	Cs-137	Cs-134	Co-60	tritium	thyroid I-129 (pCi/gm)
1967		66,956	12,313	151	46,300	
1968	543	3,793	592	< 15		
1969	95	8,587	2,046	< 15		1,200
1970	28	4,687	784	56		3,700
1971	10	1,428	314	< 15	685,550	1,400

TABLE VIII

Kr-85 levels in air in pCi/m³ 1969-1971 at Ashford and Albany (NY State data)

			average	maximum
1969	Ashford			
		Site A054145		7,860
		Site A045114		2,640
	Albany		21	88
1970	Ashford			
		Site A045145		1,640
		Site A045144		221
	Albany		19	37
1971	Ashford			
		Site A045143	1,425	
		Site A045114	137	1,516
	Albany		18	35

TABLE VIIII

Radiation dose to composite "maximum" individual exposed to maximum observed concentration of various waste products released from NFS during the first five years of operation

Nuclide	Target organ	medium	maximum concentration pCi/l or /kg	dose commitment in millirems	Total commitment in millirems
Sr-90	bone	milk	28	89	
		deer	543	227	
		fish	1679	564	
Pu	Bone	water	?	?	870
Cs-137	Whole	milk	120	2.7	
	Body	deer	67000	200	
	"	fish	3600	8.6	
Cs-134	"	deer	12313	48	
	"	fish	1550	5	
tritium	"	milk	2500	0.3	
	"	deer	683550	4.4	
	"	fish	92255	1.0	
	"	air	.12	.13	
sediments	"	bank of Cattaraugus Creek	.020 milli-R/hr.	15	
Kr-85	"	air	7.8 pCi/m^3	1.4	286.5
tritium	"	drinking Cattaraugus Creek water	184,310	17.5	
I-129	thyroid	milk	1.2	2.7	

TABLE X

Radiation dose to composite "maximum" deer exposed to and containing maximum observed concentrations of various waste products released from NFS during the first five years of operation

Nuclide	Target organ	concentration in	maximum concentration pCi/l or /kg	dose commitment in millirems	Total dose commitment in millirems
Sr-90	bone	bone	unknown	?	
Pu-238	"	"	"	?	
Pu-239	"	"	"	?	
Sr-90	whole	muscle	543	136.8	
Cs-137	body	"	66956	120	
Cs-134	"	"	12313	29.5	
tritium	"	"	683550	8.8	
"	"	air	.12	.13	
Kr-85	"	"	7.8 pCi/m^3	1.4	
sediments	"	creek banks	?	15	311.6
I-129	thyroid	thyroid	3700 pCi/gm	5600	
Pu-238	hilar	lung	.72	190	
Pu-239	nodes	"	.03	15.6	

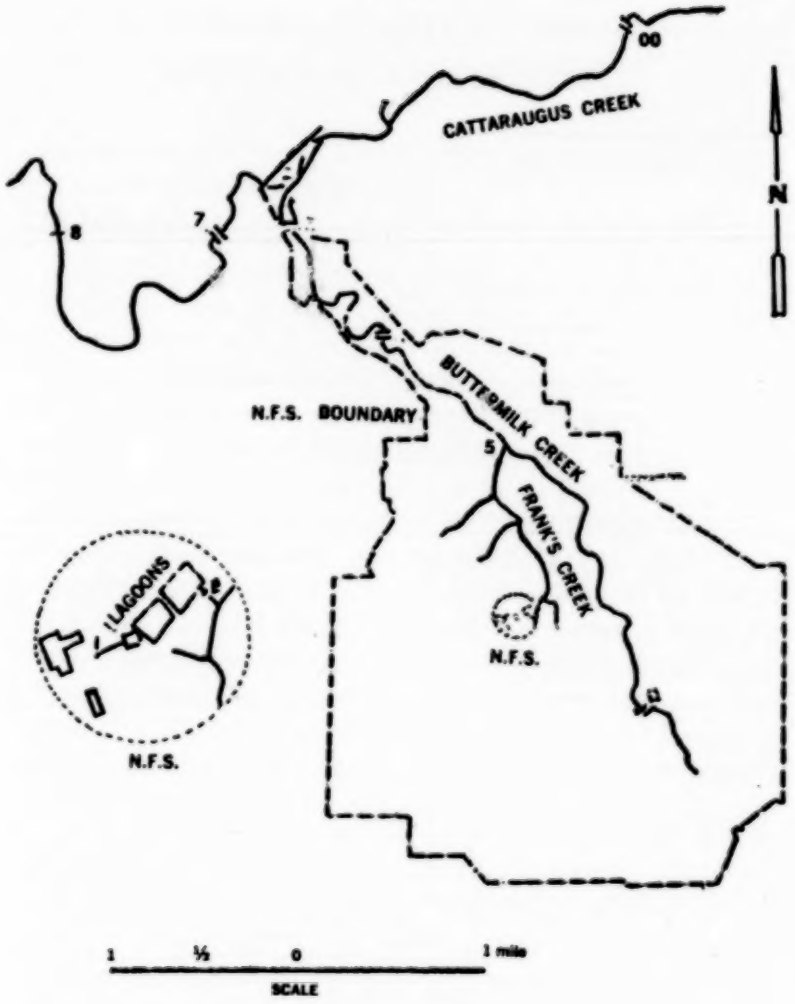

FIGURE I. Map of NFS fuel reprocessing facility, and drainage creeks.

UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

In the Matter of:	
Rule Making Hearing on Environmental Effects of The Uranium Fuel Cycle	Docket RM 50-3

Comments of General Electric Company on the Supplementary Comments by the Union of Concerned Scientists

General Electric Company has reviewed the subject filing of March 19, 1973 made by Mr. Anthony Z. Roisman on behalf of the Consolidated National Intervenors and the Union of Concerned Scientists ("CNI/UCS"). Based on our review of this document we find no additional factual evidence that would negate or substantially alter the basis proposed by the Commission for the rulemaking. These filings certainly do not support the CNS/UCS opinion expressed at the hearing in favor of a moratorium on nuclear power. In fact, we believe that viewed in the proper context these supplementary comments support the position of the Commission and other parties to this proceeding, that there are suitable answers for some of the difficult problems such as waste disposal and that the environmental effects of the fuel cycle are indeed "small" and "insignificant". Dr. Pittman testified at the hearing that a thorough evaluation is being made of various concepts for long range storage of high level wastes (Tr. 114). The CNI/UCS filing in detailing some of the primary alternatives, is clearly merely supportive of the Staff position rather than critical. While we rejoice at their general endorsement of the Staff

it is a matter of disappointment that it has been necessary to wait so long for the CNI/UCS to support the Staff position.

In addition, we would like to make the following specific comments on the CNI/UCS filing:

(1) The supplementary comments are based on facilities which have been in existence for several years and which do not yet employ the latest technology for reducing emissions and other potential environmental impacts. For example The Midwest Fuel Recovery Plant converts its high activity waste directly to a solid form rather than utilizing interim liquid waste storage. Therefore we believe as previously stated in our other submissions that actual environmental impacts will be substantially less than those indicated in the Commission's Environmental Survey. Also the Supplementary Comments of CNI/UCS greatly exaggerate the potential impact of releases from such facilities by assuming that maximum concentrations exist for an entire year and that personnel are continuously exposed. Such an approach simply is not a realistic method of estimating environmental effects.

(2) The Supplementary Comments appear to advocate the position that any calculable impact, however small, must be prohibited without any consideration of cost benefit analysis. For example, they call for immediate elimination of Kr-85 emissions without any consideration of the vast data as to the infinitesimal contribution of that isotope to radiation exposure in relation to naturally occurring sources of radiation exposure that have existed since time began.

We do not believe that such drastic restrictions are appropriate without objective assessment of their overall real impact on the quality of life and the environment.

We trust that these comments will be helpful to you in further consideration of this rulemaking proceeding. Copies of the comments have been sent to the parties shown on the attached list.

Respectfully submitted,
GENERAL ELECTRIC COMPANY
C. W. SMITH, *Manager*
Licensing & Transportation

CWS:rj

UNITED STATES OF AMERICA

ATOMIC ENERGY COMMISSION

In the Matter of	
AMENDMENT OF 10 CFR PART 50 — LICENSING OF PRODUCTION AND UTILIZATION FACILITIES (Environmental Effects of the Uranium Fuel Cycle)	Docket RM 50-3

NEW YORK STATE ATOMIC ENERGY COUNCIL COMMENTS ON SUPPLEMENTARY COMMENTS BY THE UNION OF CONCERNED SCIENTISTS ON "ENVIRONMENTAL SURVEY OF THE NUCLEAR FUEL CYCLE"

Introduction

On March 19, 1973, Consolidated National Intervenors/ Union of Concerned Scientists filed "Supplementary Comments." This document has been reviewed by members of the New York State Atomic Energy Council, and the comments contained herein are solely for the purpose of clarifying the record.

GENERAL COMMENTS

1. The Report does not recognize that there are two separate activities at the NFS West Valley Site.

(a) The processing plant and its associated burial pits —

This plant and the burial pit activities are licensed by the U.S. AEC. These burial pits (slightly south-

east of the plant) are used for disposal of high activity solid wastes and fuel hulls.

This plant began processing fuel in 1966.

(b) A commercial low level burial facility that is operated by NFS but is totally separate from the processing plant —

This facility is located southeast of the processing plant and adjacent to the pit burial area described in (a) above. The low level burial facility is licensed by New York State and the activities of the facility are monitored and inspected by appropriate New York State agencies.

2. This Report does not properly reflect that the New York State monitoring program has in the past and will in the future provide the basis for insuring that the 10 CFR 20 requirements are appropriately used to protect the public health and welfare.

3. This Report does not properly reflect the upgrading of the processing plant facilities that have already occurred or others that are scheduled and under construction at the present time. The upgrading of facilities coupled with the intensive monitoring program, provides the bases for future planned Site operations with reasonable assurance for a safe environment for the surrounding populus.

4. The Report indicates that the "specific" site soil characteristics are unknown or have not been evaluated. A series of soil tests were evaluated prior to the establishment of the plant and prior to the establishment of the low level burial facility. The extensive investigation of soil characteristics provides a high degree of assurance that these characteristics are known and that any migration from the

burial pits or the commercial burial trenches is insignificant. To date, there is no evidence of radioactive releases as a result of underground seepage from the burial facilities. There are indications that some minor amount of surface contamination may be occurring at the commercial burial facility.

There is verification that internal plant leakage of radioactive material has occurred. This is based on measurements of the sewage plant effluent activity levels. The effluent is discharged into the stream that flows past the burial area. The discharge point is upstream of the burial area.

There is a small amount of activity released in a controlled manner from a lagoon near the commercial burial trench area. Water collected in the open trench is pumped into this lagoon where it is monitored and then released. The pumping of this water has been used to maintain a dry working condition at the open end of the trench.

5. The measured fish activities listed in Table IVa through IVd yield very consistent results. These results indicate clearly that the activity levels in fish samples from the Cattaraugus Creek are substantially less than the fish samples from Buttermilk Creek. In particular, the highest isotopic entries show large decreases from Buttermilk Creek to Cattaraugus Creek. This indicates that the importance of higher isotopic levels in Buttermilk Creek is not necessarily associated directly with Cattaraugus Creek. The fish samples collected from Buttermilk Creek have indicated that the fish residing within the site boundary are smaller than normally consumed (eaten) and include primarily rough fish types. Since fishing within the site boundaries is prohibited, and given the small size of the fish normally inhabiting the site waters, the use of fish activity

levels to postulate effects on humans based on Buttermilk Creek samples is very conservative.

6. Section XIV of this Report presents a very confused description —

(a) There has been no overflow or lateral seepage of material from the commercial trenches to date that can be identified. Water has been pumped from the open trenches to a nearby lagoon where it is monitored for radioactivity and released in a controlled fashion. The low Cesium concentrations prior to 1966 referred to in the Report are probably from weapons testing fallout.

All low specific activity solid wastes from the NFS plant have been placed in the commercial burial area. The quantity of low level material from the processing plant placed in the commercial facility during 1970 is estimated to be approximately 42,000 cu. ft. The remainder of the 1970 material (approximately 80,000 cu. ft.) placed in the trench originated offsite. The trench being utilized for burial is progressively filled and covered. At any one time only 10 to 30 ft. of low level material placed in a trench remains uncovered. However, all material is packaged such that it is not directly exposed to the atmosphere. The Report is confused in associating the commercial burial facility with the processing plant and its associated burial pits.

The burial pits (under U.S. AEC license) are located adjacent to the commercial trench burial site and have been used for disposal of undissolved fuel cladding and other high specific activity solid waste. On one occasion, a small release from this area was monitored.

The rate of water migration through the soil at the NFS site was predicted by lab tests and soil sample analyses, and there is no evidence (based on soil borings and soil tests) that would support the likelihood of significant underground migration of radioactivity from the burial area.

New York State can no longer support the statement that "an estimated 14% of the Cesium and 20% of the Ruthenium found in Buttermilk Creek originates from the burial site".

(b) This Report presentation attempts to set the stage for the future by predicting that extrapolation of past releases can be used to accurately represent future releases. This fails to recognize that:

(i) Control of effluents has been and will be continued to insure the safety and health of the public;

(ii) U.S. AEC guideline limits of exposure to people have not been in the past and will not be in the future allowed to be exceeded.

SPECIFIC COMMENTS

7. **Page 3.2, Par. 8** — There is no indication of "seepage" through the soils from the pits or commercial trenches. Lagoon water discharges are controlled and monitored.

8. **Page 3.6, *First Par.*** — Undissolved cladding hulls and other high specific activity solid wastes are buried in pits located just southeast of the processing plant in accordance with U.S. AEC license requirements.

Second par. — Reference to a 1960 fuel campaign is either a typographical error or occurred at a location other than NFS.

9. Page 3.13 — The concentration limits listed on page 3.13 apply only to liquid effluents and in no way reflect limits on concentrations in drinking water.

10. Page 3.13 — The Report refers to a maximum permissible radiation dose of 500 millirem per year to bone from Sr-90, Pu-238, and Pu-239.

The correct maximum allowable dose to bone is approximately 2800 millirem per year from these elements.

11. Page 3.17 — No 7,000 ft. well has been drilled at the NFS site. Furthermore, the Oak Ridge National Laboratory study of 1971 was not conducted to evaluate the feasibility of Tritium disposal into a 7,000 ft. deep well. This study involved drilling a 1500 ft. hole and injecting a slurry with a radioactive tracer for evaluation of the shale fracturing technique for waste disposal.

12. Pages 3.16 and 3.17 — Reference is made to a survey monitoring site upstream from NFS showing "seepage" from the burial area. This is an unsupported conclusion. New York State has no definitive knowledge of seepage from the burial grounds to date. Further evaluation of possible Tritium migration is being planned.

13. Page 3.17 — The Report states that it is only a matter of time until detectable contamination of ground water occurs. This is an unsupported statement and is contrary to the test results of the site relative to soil characteristics. There is no identifiable basis that leads to a prediction of underground contamination of water outside the site boundaries.

14. Page 3.22 — The statement in the Report that activity levels in creeks will increase due to future processing of higher burn-up fuel in greater quantities, does not recog-

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nize that New York State will continue to monitor and if necessary (with the cooperation of the U.S. AEC) restrict activities at the site to prevent activity levels that would endanger the populus in the vicinity of the site. In addition, there is no recognition of the updating of NFS facilities already installed or under construction that would control the release levels.

15. Page 3.26 — The Iodine 129 releases have been recognized and facilities to insure that it is no longer released in significant amounts from the plant are under construction.

16. Page 3.37 — The 8-point fixed guidelines represent mechanisms that could be used to reduce potential exposure of people, whether the fish, water or deer were slightly contaminated or highly contaminated. Based on results to date, there is no reason to believe that any individual residing in the vicinity of the site would receive exposures higher than Federal recommended guideline dose values if he violates all the UCS guidelines listed.

17. Figure 1, Page 3.50 — The Report refers to items on this Figure that are either incorrectly displayed or not identified. These include:

(a) Erdman Brook — not identified.

(b) The two separate burial facility locations are not identified.

Respectfully submitted,

J. Bruce MacDonald
Counsel, New York State
Atomic Energy Council

Dated at Albany, New York
this 13th day of April, 1973

UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

In the Matter of AMENDMENT OF 10 CFR PART 50 — LICENSING OF PRODUCTION AND UTILIZATION FACILITIES (Environmental Effects of the Uranium Fuel Cycle)	Docket No. RM 50-3

CERTIFICATE OF SERVICE

I hereby certify that copies of "New York State Atomic Energy Council Comments on Supplementary Comments by the Union of Concerned Scientists on 'Environmental Survey of the Nuclear Fuel Cycle'" have been served on the following by deposit in the United States mail, first class, on the 16th day of April, 1973:

Max D. Paglin, Esq., Chairman
c/o Atomic Safety and
Licensing Board Panel
U.S. Atomic Energy Commission
Washington, D.C. 20545

Dr. Martin J. Steindler
411 Sandburg Street
Park Forest, Illinois 60466

Dr. John C. Geyer, Chairman
Dept. of Geography and
Environmental Engineering
The Johns Hopkins University
513 Ames Hall
Baltimore, Maryland 21218

Mr. C. Wesley Smith, Manager
Licensing and Transportation
Nuclear Fuel Department
General Electric Company
175 Curtner Avenue
San Jose, California 95114

Mr. John M. Arthur
Chairman of the Board and
Chief Executive Officer
Duquesne Light Company
435 Sixth Avenue
Pittsburgh, Pennsylvania 15219

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Mr. Donald C. Lutken, President
Mississippi Power &
Light Company
P.O. Box 1640
Jackson, Mississippi 39205

Mr. John W. Landis, President
Gulf General Atomic Company
P.O. Box 608
San Diego, California 92112

Mr. W. D. Rowe
Acting Assistant Administrator
for Categorical Programs
U.S. Environmental Protection
Agency
Washington, D.C. 20460

Professor Lawrence Ruby
College of Engineering
Department of
Nuclear Engineering
University of California,
Berkeley
Berkeley, California 94720

Mr. H. W. Brook, General
Counsel and Secretary
Nuclear Fuel Services, Inc.
6000 Executive Boulevard
Rockville, Maryland 20852

Mr. Ken Dzugan,
Research Scientist
Minnesota Pollution Control
Agency
717 Delaware Street, S.E.
Minneapolis, Minnesota 55440

Mr. John D. Hoffman
Sierra Club Legal Defense
Fund, Inc.
311 California Street
San Francisco, California 94104

Mr. Steven J. Gadler
2120 Carter Avenue
St. Paul, Minnesota 55108

Mr. Jack C. Fensterstock
Teknekron, Inc.
1619 Massachusetts Ave., N.W.
Washington, D.C. 20036

Mr. Edwin A. Wiggin, Secretary
Forum Committee on Nuclear
Fuel Cycle Services
Atomic Industrial Forum, Inc.
475 Park Avenue South
New York, New York 10016

George L. Edgar, Esq.
Morgan, Lewis and Bockius
1140 Connecticut Ave., N.W.
Suite 1100
Washington, D.C. 20036

Mr. Richard H. Stroud
Executive Vice President
Sport Fishing Institute
608 Thirteenth St., N.W.
Washington, D.C. 20005

Anthony Z. Roisman, Esq.
Berlin, Roisman and Kessler
1712 N Street, N.W.
Washington, D.C. 20036

Myron M. Cherry, Esq.
Jenner and Block
One IBM Plaza
Chicago, Illinois 60611

Mr. W. J. Dollard,
General Manager
Nuclear Fuel Division
Westinghouse Electric
Corporation
Box 366
Pittsburgh, Pennsylvania 15230

Mr. R. L. Dickeman, President
Jersey Nuclear Company, Inc.
(Exxon Nuclear Company)
777 106th Avenue, N.E.
Bellevue, Washington 98004

Dr. Leonard Geller
Vice President — Research
The S. M. Stoller Corporation
1250 Broadway
New York, New York 10001

Mr. Terry R. Lash
Natural Resources
Defense Council
36 West 44th Street
New York, New York 10036

Mr. Arnold R. Fritsch
Gulf United Nuclear Fuels Corp.
Grasslands Roads
Elmsford, New York 10523

Mr. Franklin L. Gage
27 Hastings Avenue
Croton-on-Hudson,
New York 10520

Miss Mary E. Cahoon
Box 1333
Ark. Tech.
Russelville, Arkansas 72801

J. Allen Overton, Jr., President
American Mining Congress
1100 Ring Building
Washington, D.C. 20036

Mr. W. H. Owen, Vice President
Duke Power Company
Box 2178 Power Building
Charlotte, North Carolina 28201

Mr. Richard E. Raymond,
Senior Vice President
System Engineering Operation
Florida Power Corporation
P.O. Box 14042
St. Petersburg, Florida 33733

Mr. Samuel Edlow, President
Edlow International
Suite 404-5
1100 17th Street, N.W.
Washington, D.C. 20036

Mr. H. P. Lyle, Vice President
Electric Producing
and Engineering
No. Indiana Public Service Co.
5265 Hohman Avenue
Hammond, Indiana 42365

George C. Freeman, Jr., Esq.
Hunton, Williams, Gay & Gibson
700 East Main Street
P.O. Box 1535
Richmond, Virginia 23212

Arvin E. Upton, Esq.
James P. McGranery, Jr., Esq.
LeBoeuf, Lamb, Leiby & MacRae
1821 Jefferson Place, N.W.
Washington, D.C. 20036

Mr. Frank W. Karas
Chief Public Proceedings Staff
Office of the Secretary of the
Commission
U.S. Atomic Energy Commission
Washington, D.C. 20545

James P. Murray, Jr., Esq.
Counsel, U.S. AEC
Regulatory Staff
U.S. Atomic Energy Commission
Washington, D.C. 20545

J. Bruce MacDonald
Counsel, New York State
Atomic Energy Council
99 Washington Avenue
Albany, New York
518-474-4102

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UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION
April 13, 1973

IN THE MATTER OF AMENDMENT OF 10 CFR PART 50 — LICENSING OF PRODUCTION AND UTILIZATION FACILITIES (Environmental Effects of the Uranium Fuel Cycle)	Docket No. RM-50-3

RESPONSE OF 14-MEMBER UTILITY GROUP TO "SUPPLEMENTARY COMMENTS" OF CNI-UCS

The 14-Member Utility Group submits herewith its response, prepared with the assistance of Dr. Leonard Geller of The S. M. Stoller Corporation, special consultant to the Utility Group in connection with this proceeding, to the CNI-UCS "Supplementary Comments" filed March 19, 1973.[1] The CNI-UCS Supplementary Comments addressed only two issues: high-level waste storage and the radiological effects of the NFS fuel reprocessing plant.[2]

That portion of the Supplementary Comments regarding high-level waste storage consists of an outline of various alternative methods of storing and disposing of such

[1] In the "Request of 14-Member Utility Group for Time to Review and Respond to CNI-UCS 'Supplementary Comments'", we asked to be allowed until April 16, 1973 to review the Supplementary Comments and to respond thereto. By telegraphic order dated March 29, 1973, the Board granted our request.

[2] Some subjects which the Board had requested CNI to address in its Supplementary Comments were not covered. See e.g., Tr. at 291 (Dr. Steindler expressed the hope that in light of the CNI-UCS approach to the question of accident analysis, CNI-UCS could address the shortcomings which CNI-UCS sees in the Fuel Cycle Survey's accident analysis.)

wastes. CNI-UCS favors the alternative of separating the transuranics and actinides from the fission products and subjecting the transuranics and actinides to transmutation. The outline of alternatives could serve as a primer for those who may be unacquainted with the high-level waste storage issue. As we note herein, the CNI-UCS transmutation recommendation is one that has been and is being considered by the Commission. While the CNI-UCS comments regarding high-level waste storage may be of some limited usefulness in providing background information, they are not relevant to the issues involved in this proceeding. This rule making is concerned with two questions: (a) the accuracy of the Survey's calculation of the environmental effects of the uranium fuel cycle and (b) the method by which those calculated environmental effects are to be taken into account in the licensing of light-water-cooled nuclear power reactors. The Hearing Board is not charged with the duty of setting broad Commission policy regarding high-level waste storage nor is this rule making concerned with the question of which alternative method of storing and disposing of high-level waste should be adopted.[3] While we would be pleased to debate the merits of the CNI-UCS transmutation recommendation in the proper forum, we do not believe the purpose of this proceeding would be advanced by engaging in that tangential debate now. However, we have briefly addressed, in the attached comments, certain statements of CNI-UCS regarding the waste management question which we believe are unduly exaggerated.

With respect to the CNI-UCS comments regarding the NFS fuel reprocessing plant, significant modifications made and being made to the NFS plant will significantly reduce

[3] There are fora available to CNI-UCS in which it can argue its transmutation recommendation. For example, the JCAE recently held hearings on the AEC waste management program. Apparently, however, no nuclear critics requested an opportunity to participate in those hearings and reportedly none attended the hearings.

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the discharge of radioactive elements, such as Cs-137, Sr-90 and I-129, about which CNI-UCS has expressed concern. These modifications are alluded to by CNI-UCS in the Supplementary Comments but the significance of such modifications was not discussed therein. Equally important, as we point out in greater detail herein, is the fact that even absent such modifications the radiation exposure from the NFS plant would be significantly lower than the exposure calculated in the CNI-UCS Supplementary Comments. In any event, the NFS plant is atypical of current reprocessing operations and will provide only a part of the total reprocessing capacity available in the near future. The CNI-UCS Supplementary Comments thus fail to treat the NFS plant in the proper perspective — *i.e.*, in the context of the total reprocessing industry.

Thus, our final review confirms our initial assessment that the Supplementary Comments raise no major, critical questions and adduce no significant factual data which controvert the validity of the Fuel Cycle Survey.

Respectfully submitted,

Baltimore Gas and Electric Co.
Boston Edison Co.
Consumers Power Co.
General Public Utilities Corp.
Long Island Lighting Co.
New England Electric System
Northeast Utilities Co.
Pacific Gas and Electric Co.
Philadelphia Electric Co.
Public Service Electric & Gas Co.
San Diego Gas & Electric Co.
Southern California Edison Co.
Virginia Electric and Power Co.
Yankee Atomic Electric Co.

George C. Freeman, Jr.
David S. Brollier

1058/389

Hunton, Williams, Gay & Gibson
700 East Main Street
P. O. Box 1535
Richmond, Virginia 23212
Of Counsel

REVIEW OF CNI-UCS SUPPLEMENTARY COMMENTS

I. REVIEW OF CHAPTER 2 ENTITLED "STORAGE AND DISPOSAL OF HIGH LEVEL WASTES"

Chapter 2 of the Supplementary Comments consists merely of a review of the current effort to deal with the storage and disposal of high-level wastes and an outline of various alternatives which might be considered. CNI-UCS favors separation of transuranics and actinides from the fission products and transmutation of the former — an alternative which has been and is being considered by the AEC. The CNI-UCS review and outline is not particularly relevant to this proceeding; however, Chapter 2 does contain certain statements which we feel are deserving of reply.

For example, at 2.2 of the Supplementary Comments, CNI-UCS claims that the current AEC program for storage and disposal of nuclear wastes is 'reminiscent" of developments associated with the production of plutonium for the weapons program: "Hasty and, in part, seriously incorrect decisions were made regarding the storage of wastes produced by a technology alleged to be currently necessary." We do not believe that the Commission's program can accurately be characterized as encouraging hasty decisions regarding the ultimate disposal problem. On the contrary, the approach being followed by the Commission — putting the wastes in a solidified form so that they can be conveniently handled and stored in an Engineered Storage Facility (ESF) until the ultimate disposal question is resolved — removes the pressure that might otherwise exist to make hasty decisions about ultimate disposal. Moreover, the ESF will provide an added measure of protection since the flow of high-level wastes is not expected to become appreciable until the early 1980's and storage at reprocessing plant sites, even as liquid wastes in stainless steel tanks, is a

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feasible, demonstrated technique to use until another technique, meeting the long-term objectives, is established.

As far as the notion that "seriously incorrect decisions" were made in the storage of wastes from the weapons program, we interpret this as referring to the use of carbon steel tanks, particularly single tanks, for much of the storage capacity at Hanford and Savannah River. Actual experience over more than 25 years has shown that the leaks from these tanks (which the testimony considers further on page 2.14) have not caused any harm to site personnel or to the public. Moreover, the initial use of these single tanks has not precluded their replacement by improved designs as the need for additional capacity has developed. No irrevocable decisions affecting the environment have been made by their use.

Neither do we believe that the possible lack of a satisfactory method to decontaminate the carbon steel tanks is adequate reason to classify the use of such tanks as a "serious mistake". The potential adverse environmental effects are sufficiently remote that such tanks may be justified even after a strict NEPA cost-benefit analysis, as demonstrated by the recent (Dec. 1972) Environmental Statement submitted for Future High Level Waste Facilities at Savannah River. (1) In this report, four carbon steel tanks, each having a capacity of 1.3 million gallons, are proposed for construction to hold the alkaline wastes from future processing operations. The carbon steel tanks are shown to have a higher benefit-cost ratio than would the use of acid wastes and stainless steel tanks.

At page 2.9 of the Supplementary Comments, CNI-UCS states:

> "Plutonium (Pu) is perhaps the most toxic element known and represents a chronic biological hazard on a weight basis comparable to the acute hazard from *botu-*

linus toxin, i.e., it is hazardous at 10^{-6}g, if appropriately deposited in lungs or bone (5). 239Pu in equilibrium with its daughters has a direct radiological hazard about 10,000 times that of natural uranium in equilibrium with its daughters (6)."

There is no question that Pu-239 and its decay products are highly hazardous materials and must be treated with the careful attention they deserve. But the article by A. Weinberg (2), referred to in the above quote from the Supplementary Comments, gives some perspective regarding Pu-239's toxicity. In referring to what might happen if the worst foreseeable catastrophe should strike the salt mine containing the high-level wastes accumulated from now until the year 2000, Weinberg says:

"The mine would contain 38 tons of ^{239}Pu mixed with about a million tons of nonradioactive material. The plutonium in the cans is thus diluted to 38 parts per million; since plutonium is, per gram, 10,000 times more hazardous than natural uranium in equilibrium with its daughters, these diluted waste materials would present a hazard of the same order as an equal amount of pitchblende. Actually, the 38 tons of ^{239}Pu is spread over 200 acres. If all the salt associated with the ^{239}Pu were dissolved in water, as conceivably could result from total flooding of the mine, the concentration of plutonium in the resulting salt solution would be well below maximum permissible concentrations. In other words, by virtue of having spread the plutonium over an area of 200 acres, we have to a degree ameliorated the residual risk in the most unlikely event that the mines are flooded."

This same point — that the toxicity of plutonium may be diluted to a point where it is comparable to that of other natural background elements — has also been made by Julius H. Rubin, AEC Assistant General Manager for Environment and Safety, in discussing waste disposal (3):

"In terms of long half-life and high specific radiotoxicity, plutonium-239 is comparable to radium-226. The current maximum permissible body burden for plutonium in bone

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is two and one-half times more restrictive than that for radium. The concentration standard for water is 500 times more restrictive for radium than for plutonium. The half-life of plutonium is 15 times as long as that of radium. However, the half-life of radium is only relevant to specific isolated quantities: the radium content of the earth's crust in general is maintained by the decay of uranium-238, with a half-life about 2 x 10^5 times as long as that of plutonium. In view of the long periods of time involved in this general problem, estimation of an exact 'relative hazard factor' seems unwarranted. Radium is widely dispersed through the earth's crust, frequently near the surface. The resultant concentrations of radium in natural waters are often detectable but are generally well below drinking water standards. It seems reasonable, therefore, to bury plutonium — not at random, but at carefully selected sites — in concentrations in the upper range of natural radium concentrations in the earth. The actual value proposed is ten nanocuries per gram of waste."

Thus, plutonium may be stored and disposed of in such a manner as to represent no greater threat than other naturally occurring elements.

References:

(1) WASH-1528 "Draft Environmental Statement — Future High Level Waste Facilities" — Savannah River Plant — Aiken, South Carolina, Dec. 1972-USAEC

(2) A. M. Weinberg, Science 177, 27 (1972)

(3) J. H. Rubin, "High-Level Radioactive Waste Management in the U.S.", IAEA Panel to Examine the Possibility of Establishing International Storage Sites for High-Level and Alpha Bearing Radioactive Wastes, Nov. 20-24, 1972 — Vienna, Austria.

II. REVIEW OF SECTION 3 ENTITLED "RADIOLOGICAL IMPACT OF WEST VALLEY REPROCESSING PLANT"

It is interesting that CNI-UCS has focused upon data associated with the NFS plant. As EPA has pointed out in a recent (August 1972) report, "Estimates of Ionizing Radiation Doses in the United States — 1960-2000", the NFS reprocessing operation "is not considered typical of future plants" (p. 32). Indeed, the Fuel Cycle Survey itself makes clear that the NFS plant is atypical of the industry, since "only the NFS plant releases radionuclides in liquid effluents" (p. F-25). Furthermore, as the Fuel Cycle survey points out, not only is the NFS plant atypical of current reprocessing operations, but it will provide only a fraction of the total reprocessing capacity available within the near future. Thus, the CNI-UCS focus upon only the NFS plant is not particularly helpful in forming a clear assessment of the environmental effects of the reprocessing phase of the uranium fuel cycle. Even if the additional adverse environmental effects postulated by CNI-UCS with respect to the NFS plant were correct, the additional contribution of such effects must be viewed in the context of the total reprocessing industry.

While the CNI-UCS focus upon the NFS plant represents a distorted perspective, that distortion is compounded by the methodology used in calculating the anticipated radiological impact of the plant. Most importantly, CNI-UCS relies upon the earlier historical data of NFS and suggests that the discharge levels during this earlier period will continue. (It is worth noting that the NFS discharges never exceeded the then applicable discharge envelope, nor does CNI-UCS so allege.) Yet, as CNI-UCS itself notes, a number of improvements have been made to the plant (most

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notably, a new Low Level Waste Treatment facility) which will reduce the discharge levels. But while CNI-UCS refer to these improvements, their effect in reducing radionuclide discharge levels is never discussed. However, the data cited by CNI-UCS (see Tables IIIa, IIIb, IVa, IVb, IVd and VII) clearly demonstrate that the radwaste system modifications introduced in 1971 have been very successful in reducing such effluents. Additional modifications currently being made in connection with off-gas treatment can also be expected to yield reduced I-129 effluent levels. Thus, the past NFS experience has led to advances in reprocessing technology and improvements in environmental and radiological impact reductions and, in this regard, represents an outstanding example of the dynamic nature of the regulatory process. However, without consideration of existing and planned modifications, the past NFS experience does not constitute a valid base upon which to project future performance.

The final objection to the CNI-UCS testimony is the fact that data were often inappropriately applied in computing radiological impacts. In each case maximum release levels, concentration values, etc., have been used as the basis of dose estimates. While we do not object to CNI-UCS postulating a "worst possible case" of radiological impact, the case postulated by CNI-UCS is not a "possible" one, since it is physically impossible to sustain the maximum levels for the entire year, if for no other reason than the batch nature of the process.

The NFS modifications and their significance and the inappropriate use of maxima are further discussed below. As a summary and illustration of the extent to which CNI-UCS has miscalculated the NFS radiological impact, we present Table 5, which should be compared to CNI-UCS Table VIIII (*i.e.*, Table IX). Table 5 sets forth the com-

posite average and maximum human exposure experienced after the introduction in 1971 of the radwaste modifications.

Finally, the CNI-UCS Supplementary Comments suggest proposed revisions to current Commission regulations (*e.g.*, application of human radiological standards to wildlife). While these suggestions patently fall outside the scope of this proceeding, we address them briefly below. Certain additional comments are also set forth below.

System Modifications — As has been alluded to in the CNI-UCS testimony, there has been, in the past, some concern expressed about radionuclides released in liquid effluents. Review of the situation by AEC, NFS and New York State resulted in the decision to augment the liquid waste treatment system. Design efforts were begun on this program in 1968 and the Low Level Liquid Waste Treatment (LLWT) facility became operable in May 1971. The lower 1971 concentration values reported by CNI-UCS (Tables IIIa, IIIb, IVa, IVb, IVd and VII) reflect the good results obtained from operation of this system. Table 5 herein demonstrates the reduced maximum human exposure resulting from such modifications. The assertion by CNI-UCS that this downward trend will "no doubt" reverse itself is based on two misconceptions.

The primary misconception is that processes and treatment systems, once installed, are static in nature. On the contrary, the technological and regulatory framework of the nuclear industry is such that systems and regulations are evolutionary in character. In the case of the LLWT facility, performance is reviewed both by NFS and the AEC and further work is being conducted. In the six-month summary of the LLWT facility (6), NFS indicates that the system was installed because it was "practicable"

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to use it for effluent reduction. It further characterizes the system performance, the operational problems encountered, and the actions taken to resolve those problems. In particular, some degradation of resins was observed due to regeneration with nitric acid, and other methods of regeneration (with sulfuric acid, for instance) were being studied. The following table was presented by NFS to characterize system performance.

Average Percent Removal Low Level Liquid Waste Treatment Facility

	June Through Nov. 1971	Sept. Through Nov. 1971
Cs137	87	95
Sr90	80	95.5
Ru-RH106	68	68
Gross B	81	81

A second CNI-UCS misconception is that the reduced effluent levels will increase once higher burnup fuel is reprocessed. To some extent, the NFS plant has been reprocessing higher burnup fuel and the effluent levels nevertheless continue to be reduced as a result of the LLWT facility, since the throughput of higher burnup fuel was considered in the design of the LLWT facility. Moreover, it appears likely that the typical burnup of fuels processed until the end of this decade will be closer to 30,000MWD/MT burnup than to the 40,000MWD/MT figure, primarily because most of the reprocessing load will be from first cores. First cores experience lower burnup by about ⅓ than do equilibrium cores. The consideration by CNI-UCS of 40,000MWD/MT fuel (pp. 3.7, 3.29) is not believed to be representative of facility operation.

It should also be noted that CNI-UCS has not taken into account the operation of the LLWT facility in the discussion (pp. 3.24-3.25) regarding leakage from the NFS burial grounds. While there has been, in the past, some release of radioactive liquids from the burial ground trenches, it is our understanding that these liquids are now routed through the LLWT facility for processing prior to release from the site.

A further plant modification currently being made is the installation of a new gaseous waste treatment system. The most dramatic effect is expected to be in the area of I-129 releases, with greater than 99% removal anticipated. The system has been designed for continuous operation during dissolution, thereby essentially eliminating this source of release to the environment.

Dose Computations—The dose commitment estimate presented by CNI-UCS is misleading because it considers only the case of the individual exposed to the highest concentration that was ever observed for a particular isotope since start of plant operations and whose intake is also a maximum. As pointed out above, the use by CNI-UCS of maximum concentrations is completely unrealistic, because it is physically impossible for NFS to maintain, throughout the year, the maximum discharge levels.

A more realistic dose commitment estimate was made by the Public Health Service in a 1968 study of the NFS radiological conditions (3). That study treated both the average and the maximum human exposure, but the basic analytical approach used in the PHS study was very similar to that of CNI-UCS: the study considered maximum (and average) concentration levels and maximum (and average) intake models and made the conversion from intake to dose commitment. The PHS study discusses the validity of the

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model for continuous intake situations, which can be treated as a series of discrete intakes.

Tables 1-4 herein present the PHS data as reported in reference (3). Although the *dose commitment* values reported by CNI-UCS are not supported by a reference, it is assumed that they are based upon the PHS study and that any variations between the CNI-UCS values and the values in the PHS study are due to differences in rounding off. Of more significance, we believe, is the apparent discrepancy between some of the *concentration* values used by each, and the method of choice of some values by CNI-UCS (for example, use of Sr90 concentrations in bottom rather than surface feeders).

As a result of the investigation, the PHS study concluded that the presence of NFS "based on data presently available, did not significantly increase the radiation dose to the 'typical individual' in 1968 above that due to fallout and natural radiation." The PHS did recommend further study in terms of population, size and location, measured intake by man and animals, and additional monitoring of environmental nuclide levels. One part of the recommended study has already been performed. This is the I-129 investigation in milk samples conducted by the New York State Department of Environmental Conservation. A corollary study was performed by the PHS itself (4). As discussed above in the section on System Modifications, as a result of these studies, modifications are being made to the plant which will reduce the level of I-129 releases. As the New York State Department of Environmental Conservation has noted, I-129 has a short field half-life when the releases from the NFS plant are reduced (5).

For purposes of comparison, we present in Table 5 a dose estimate based on 1971 operation as reported by the New

York State Department of Environmental Conservation (6) and using the same assumptions as the Public Health Service (outlined above). It may be observed that there is an appreciable reduction compared to Table 4 in both average and maximum doses from Strontium and Cesium due primarily to the use of the new LLWT facility.

Current Regulations — Existing U. S. regulations for release of radioactive material are based on protection of man from the effects of radiation. Limits are imposed on concentrations in unrestricted areas in which the facility owner is unable to regulate access by members of the public. These are the basic features of the regulations to which UCS is taking exception. Specifically, UCS suggests that release limits be applied in Buttermilk Creek, which is within the restricted area owned by NFS; that human standards be applied to all wildlife found on the NFS property; and that the nonmedical radiation dose values be allocated among various parts of the nuclear industry.

As to the CNI-UCS recommendation that the total permissible population exposure be allocated among sources, we would observe that the AEC is moving in this direction, as exemplified by its proposed Appendix I ("as low as practicable") levels for nuclear power plants. However, since the National Academy of Sciences (NAS) — National Research Council (NRC) Committee has not established or suggested numerical values (2), we believe that the CNI-UCS recommendation of 5-10% of current limits (p. 3.1, p. 3.23) should not merely be mentioned in passing but should have firm substantiation before being considered. It should be noted also that the NFS Technical Specifications provide for a limit on liquid releases of 20% of current AEC regulations on a weekly basis and less than 10% of these levels for a quarter.

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The suggestion to apply human radiological standards to wildlife appears unnecessary, since the available data indicates that man is more radiosensitive than other species. Indeed, the NAS-NRC Committee has concluded that "if man as an individual is protected, then other organisms as populations would be most unlikely to suffer harm." (1) The additional admonition by the NAS-NRC Committee that "there should not be attempted the reduction of small risks even further at the cost of large sums of money that spent otherwise, would clearly produce greater benefit" is particularly applicable to these suggested regulatory revisions.

The CNI-UCS recommendation that the radiological releases into Buttermilk Creek be reduced has already been satisfied, to a large extent, by the introduction of the LLWT facility. Further restrictions on releases into Buttermilk Creek appear to us to be unnecessary. The data in Tables IV(a-d) of the Supplementary Comments clearly show that the maximum values of the isotopes measured in Cattaraugus Creek fish are consistently lower than the levels found in Buttermilk Creek fish. This indicates that there is no significant migration of fish from Buttermilk Creek to Cattaraugus Creek. Thus, it appears highly unlikely that the dose received by those fishing in Cattaraugus Creek will be affected by the concentration levels in Buttermilk Creek fish.

Additional Comments — There are a few specific comments which we believe should also be made with regard to the testimony, as follows:

1) p. 3.5 The values cited in Section IV as NFS estimates of annual load in 1975 and 1980 — 125 tons and 2950 tons, respectively — are the total anticipated loads for the total reprocessing industry, not the loads for the NFS facility.

2) p. 3.6 It appears that the 1960 date mentioned in the second paragraph is a typographical error since the facility began operating in 1966.

3) p. 3.9 We believe that liquid discharges are no longer released from lagoon 3 as indicated in the first paragraph but routed through lagoons 4 and 5 before release.

4) p. 3.17 The second column of the table on the bottom of the page should be Pu-239.

5) p. 3.20 The last sentence of the first paragraph should read "32 [not 454] millirems for that year."

6) p. 3.24 CNI-UCS has not presented references or factual bases for several of its statements. Examples of this approach may be found in the phrases on this page — ". . . . contains significant amounts of activity . . ." and "It is estimated that . . ."

7) p. 3.28 The Kr85 limit quoted in the third sentence from the bottom should be 3×10^{-7} micro Ci/cc. The value listed is for Kr85m.

8) p. 3.29 The Statement concerning EPA's recommendation of Kr85 recovery systems for nuclear power plants should be documented, if possible. In a recently published report, staff members of EPA's Office of Radiation Programs stated — "Whether it is worthwhile or even desirable to exert further effort to contain the residual krypton-85 is doubtful at the present time." The report further stated that "the potential hazards associated with retaining cylinders of krypton-85 and methods for ultimate storage for about 100 years require further evaluation."(7)

9) pp. 3.30, 3.32 CNI-UCS again uses unquantified terms such as "small," "not inconsequential", "singificant" and "measurable".

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10) p. 3.47 It should be noted that the average 1971 value reported for site A045143 (1,425pci/M^3 Kr85) is based on only one measurement at this site. As such, the term "average" appears inappropriate.

References:

(1) "Estimates of Ionizing Radiation Doses in the United States 1960-2000", U. S. EPA-ORP/CSD72-1, August 1972.

(2) "The Effects on Populations of Exposure to Low Levels of Ionizing Radiation", National Academy of Sciences — National Research Council, November 1972.

(3) "An Estimate of Radiation Doses Received by Individuals Living in the Vicinity of a Nuclear Fuel Reprocessing Plant in 1968," U. S. Dept. of Health, Education & Welfare — BRH/NERHL 70-1, May 1970.

(4) "Iodine-129 in the Environment Around a Nuclear Fuel Reprocessing Plant" — U. S. EPA, Office of Radiation Programs, October 1972.

(5) "Radioactivity in Air, Milk and Water for July-September 1972," New York State Department of Environmental Conservation Environmental Radiation Bulletin 72-3, January 1973.

(6) Docket 50201-97, Six Month Summary of Low Level Liquid Waste Treatment Facility," November 1971.

(7) Martin, James E., Galpin, Lloyd L., and Fowler, Ted. W., "Technology Assessment of Risk Reduction Effectiveness of Water Treatment Systems for Light-Water Reactors," Radiation Data & Reports, January 1973 pp. 1-8.

Table 1 — Factors for Calculating Dose Commitments

Radionuclide[a]	Critical organ	Mode	Dose commitment factor[b] (millirem per 50 year per μCi intake)
^{90}Sr (7)	Bone	Ingestion	$8.4 \cdot 10^3$
^{137}Cs (7)	Whole body	Ingestion	$0.06 \cdot 10^3$
^{134}Cs (12)	Whole body	Ingestion	$0.08 \cdot 10^3$
^{60}Co (12)	G.I. tract	Ingestion	$0.04 \cdot 10^3$
^{106}Ru-Rh (12)	G.I. tract	Ingestion	$0.195 \cdot 10^3$
^{3}H (7)	Whole body	Ingestion	0.13
^{3}H (14)	Whole body	Inhalation and skin absorption	[c] $1.87 \cdot 10^6 X_a$
^{85}Kr (14)	Whole body	Submersion in Air	[c] $2.08 \cdot 10^6 X_a$

[a] Reference from which dose model was obtained in parenthesis.

[b] Dose commitment refers to the dose delivered (in millirem) to a critical organ during a 50-year period (or during life) from a particular intake.

[c] X_a (concentration is in terms of μCi/liter) dose is in terms of millirem delivered for the first year after exposure which in this case is analagous to the dose commitment.

(7) SHLEIEN, B. An evaluation of internal radiation exposure based on dose commitments from radionuclides in milk, food, and air. Health Physics 18:267 (1970).

(12) COSWER, K. E., KAYSE, S. V., ROHWER, P. S., SNYDER, W. S. and STRUXNESS, E. G. Dose estimation studies related to proposed construction of an Atlantic-Pacific Interoceanic Canal with nuclear explosives: Phase I, ORNL-4101, Oak Ridge National Laboratories, Oak Ridge, Tennessee (1967).

(14) COWSER, K. E. and TADMOR, J. Krypton-85 and tritium in an expanding world nuclear power economy, in Health Physics Div. annual progress report for period ending July 31, 1968 ORNL-4316, Oak Ridge National Laboratories, Oak Ridge, Tennessee (1968).

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Table 2 — A Summary of Yearly Dietary Intakes & Exposure Times

Media	Typical	Maximum
Milk	310 liter	380 liter
Deer	2 kg	50 kg
Fish	5.5 kg	40 kg
Drinking water	440 liter	730 liter
Air	8,736 hours	8,736 hours
River bank	0 hours	200 hours

Table 3 — Concentrations of Radionuclides in Environmental Media Collected Around NFS in 1968 (μCi/liter or μCi/kg)

Radionuclide	Media	Average	Maximum
^{90}Sr	Milk	$11 \cdot 10^{-6}$	$21 \cdot 10^{-5}$
	Deer[a]	$11 \cdot 10^{-5}$	$54 \cdot 10^{-5}$
	Fish[b]	$34 \cdot 10^{-5}$	$64 \cdot 10^{-5}$
^{137}Cs	Milk	$27 \cdot 10^{-6}$	$12 \cdot 10^{-5}$
	Deer	$13 \cdot 10^{-3}$	$67 \cdot 10^{-3}$
	Fish	$63 \cdot 10^{-5}$	$36 \cdot 10^{-4}$
^{134}Cs	Deer	$26 \cdot 10^{-4}$	$12 \cdot 10^{-3}$
^{60}Co	Deer	—	$90 \cdot 10^{-6}$
	Fish	$21 \cdot 10^{-5}$	$30 \cdot 10^{-5}$
^{106}Ru-Rh	Fish	$85 \cdot 10^{-5}$	$21 \cdot 10^{-4}$
^{3}H	Milk	$< 12 \cdot 10^{-4}$	$23 \cdot 10^{-4}$
	Deer	$30 \cdot 10^{-3}$	$46 \cdot 10^{-3}$
	Fish	$12 \cdot 10^{-3}$	$50 \cdot 10^{-3}$
	Drinking water	$< 3 \cdot 10^{-3}$	$10 \cdot 10^{-3}$
	Air[c]	$3 \cdot 10^{-8}$	$8 \cdot 10^{-8}$
^{85}Kr	Air	$23 \cdot 10^{-9}$	[d]$13 \cdot 10^{-8}$

[a] Deer — meat only.

[b] Fish — whole fish.

[c] Survey carried out in 1967.

[d] Survey carried out in 1969.

Table 4 — Dose Commitment Accrued in 1968 in the Vicinity of Nuclear Fuel Service

Radionuclide	Critical organ	Media	Dose commitment[a] (millirem) Typical individual	Maximum individual
^{90}Sr[b]	Bone	Diet[c]	77	90
		Deer	1.9	227
		Fish	16	[d]215
^{137}Cs	Whole body	Diet	1.7	4.5
		Deer	1.6	[e]200
		Fish	0.2	8.6
^{134}Cs	Whole body	Deer	0.4	48
^{60}Co	G.I. tract	Deer	<0.01	0.2
		Fish	0.05	0.5
^{106}Ru-Rh	G.I. tract	Fish	0.9	16.4
^{3}H	Whole body	Diet	<0.1	0.3
		Deer	0.1	0.3
		Fish	<0.01	0.3
		Drinking water	<0.17	1.0
		Air (Inhalation and skin absorption)	<0.05	0.1
^{85}Kr	Whole body	Submersion in air	0.05	0.3

[a] Dose per 50 years or per lifetime.

[b] For ^{90}Sr ~7 percent of the dose commitment to bone delivered is delivered during the first year after intake:

Diet: 5.4 millirem (typical) and 6.3 millirem (maximum).

Deer: 0.1 millirem (typical) and 16 millirem (maximum).

Fish: 1.1 millirem (typical) and 15 millirem (maximum).

For other radionuclides > 90 percent of the dose delivered in the first year after intake.

[c] Diet intake indirectly determined through use of radionuclide value reported in milk.

[d] Represents whole fish. The majority of ^{90}Sr concentrates in bone which is usually considered inedible. Therefore the dose commitment may represent a high estimate.

[e] From sample caught onsite.

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Table 5 — Dose Commitment Accrued in 1971 in the Vicinity of NFS

Radionuclide	Media	Concentration (mCi/l or Mci/kg)		Dose Commitment (mrem)	
		Average	Maximum	Average	Maximum
1129	Milk	0.4×10^{-6}	0.9×10^{-6}	0.9	2.0
Sr90	Diet(1)	9.4×10^{-6}	19×10^{-6}	66.2	81.9
	Deer(2)	3.33×10^{-6}	10×10^{-6}	.06	4.2
	Fish(3)	10×10^{-6}	45×10^{-6}	.46	1.5
Cs137	Diet(1)	4.6×10^{-6}	36×10^{-6}	.29	3.3
	Deer(2)	3.94×10^{-4}	1.428×10^{-3}	.05	4.3
	Fish(3)	4.74×10^{-4}	1.666×10^{-3}	.16	4.0
Cs134	Deer(2)	69.8×10^{-6}	3.14×10^{-4}	.01	1.3
Co60	Deer(2)	Not Measured	Not Measured	—	—
	Fish(3) (+) only one detectable measurement	—	23×10^{-6}	—	.04
Ru-Rh106	Fish(3)	ND	ND	—	—
H3	Diet(1)	ND	1.170×10^{-3}	—	.15
	Deer(2)	.232	.684	.06	4.4
	Fish(4)	33.2×10^{-3}	1.8×10^{-1}	.02	.96
	Water	33.2×10^{-3}	1.8×10^{-1}	1.9	17.5
	Air (Inhalation)	Not Measured	Not Measured	—	—
Kr85	Air (Submersion)	65×10^{-9}	691×10^{-8}	.14	1.4

(1) Dietary levels determined from milk measurements — as discussed by the PHS — based on field measurement —
Sr90 intake — milk is 37% of total dietary intake
Cs137 — milk is 30% of total dietary intake
H3 — milk is 40% of total dietary intake
(2) Measured levels in deer muscle.
(3) Measured levels in fish flesh.
(4) Assumed same as in water.

UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

In the Matter of AMENDMENT OF 10 CFR PART 50 — LICENSING OF PRODUCTION AND UTILIZATION FACILITIES (Environmental Effects of the Uranium Fuel Cycle)	Docket No. RM-50-3

NUCLEAR FUEL SERVICES, INC. RESPONSE TO UNION OF CONCERNED SCIENTISTS

Nuclear Fuel Services, Inc. (NFS) welcomes the opportunity to submit a response to the Supplementary Comments by the Union of Concerned Scientists (UCS) on Environmental Survey of the Nuclear Fuel Cycle. Our participation in this proceeding has previously been limited to joining with the Atomic Industrial Forum in the views presented by that organization which we believed pertinent to the matter in issue. We believe the UCS comments add little to the resolution of the questions in issue, but we are compelled to submit a response to UCS since they purport to deal in length with the radiological impact of the NFS fuel reprocessing plant (Plant). The UCS statement is replete with grossly misleading interpretations of data, and proposes findings, conclusions, and recommendations concerning the operations of the Plant grounded on fundamentally erroneous technical and scientific bases.

After UCS so thoroughly criticized the AEC staff for allegedly omitting supporting references and substituting

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adjectives for quantification in its "Environmental Survey of the Nuclear Fuel Cycle," it is shocking to note that the UCS statement is guilty of the very same type of omissions. Additionally, the UCS statement lacks any semblance of scientific, objective presentation, and selectively omits data pertaining to matters that it discusses. A sampling of specific deficiencies of the UCS statement are discussed below.

UCS begins with the premise that the confluence of Buttermilk Creek and Cattaraugus Creek is located beyond NFS controlled property (p. 3.4). UCS treats Buttermilk Creek as though all of it is opened to the public for fishing and other activities and calculates potential exposures to radiation on that basis. However, the fact is that the confluence of Buttermilk Creek and Cattaraugus Creek is located entirely within NFS property. Buttermilk Creek is not open to the public for fishing or any other purpose downstream of the Plant. Thus, the UCS calculations of potential exposures based on this erroneous premise are meaningless from a technical and scientific standpoint.

UCS first describes the interceptors and lagoons at the Plant as they existed prior to installation of the Low Level Waste Treatment facility (p. 3.8-3.10). No useful purpose is served by this outmoded description. UCS fails to place this discussion into appropriate context by failing to note that only limited operations were carried on within these initial facilities, that all such operations were carried on in strict compliance with all the applicable regulations, that careful monitoring was performed to assure that the desirability of any improvements would be readily detected and that such improvements were promptly adopted. Thus, UCS obviously sought only to castigate past experience without seeking to include within the record the meaningful improvement achieved on the basis of such experience.

UCS then discusses liquid discharges by the Plant on the basis of data presented in its Table II purportedly summarizing the activity discharged by the Plant from 1966 through 1969 (p. 3.10). Table II is more significant for what has been omitted from it than for what has been included in it. What have been omitted are figures for 1970 and 1971, which figures would show significant decreases in gross beta activity. Apparently, UCS is making an unscientific deliberate attempt to ignore the improvements that have been brought about at the Plant with the installation of the Low Level Waste Treatment facility since data as late as 1972 is contained elsewhere in the UCS statement.

UCS discusses various results of monitoring by the State of New York and presents selected results in its Table III (p. 3.12). Again, Table III is more significant for what has been omitted from it than for what has been included in it. Gross beta activity has been omitted which would have shown absolutely no increasing trend. More significantly, while UCS notes that the State of New York maintains its data in terms of average, minimum, and maximum concentrations, UCS Table III shows only the maximum concentrations. It appears that UCS is unwilling to have its calculations and conclusions based on maximum data placed in context by showing all of the data collected by the State of New York.

UCS in discussing the maximum permissible water concentrations and radioactive contamination of creeks (p. 3.12-3.18) shows a remarkable misunderstanding of the AEC regulations prescribing concentration limits. This misunderstanding is exemplified by UCS' statement that the maximum concentration limits "assume that only a single isotope is present." Apparently, UCS is unaware that the

maximum concentration limits are applicable to all isotopes on a pro rata basis such that

$$\frac{\text{Con} - \text{X}}{\text{MPC-X}} + \frac{\text{Con} - \text{Y}}{\text{MPC-Y}} + \frac{\text{Con} - \text{Z}}{\text{MPC-Z}} = 1.$$

UCS has made a number of comparisons, calculations, and conclusions using maximum data concerning radioactivity concentrations in fish and projecting the potential radiation exposure to a fisherman (p. 3.18-3.22). Since the fisherman cannot select and ingest only those fish with the maximum concentrations it is unreasonable to calculate the resulting radiation exposure from these maximum concentrations. The calculation of dose from ingesting Buttermilk Creek trout is misleading. This stream is not open to the public for fishing and, in addition, it is highly doubtful that the stream contains a 1 kg. trout. The New York Department of Environmental Conservation (NYDEC) has obtained only five to six trout from this stream in all the years of sampling and these specimens have ranged between six and eight inches (0.2 kg. to 0.4 kg.). If modern shocking techniques must be used by NYDEC to obtain these few specimens, it is doubtful that a fisherman would successfully obtain trout in the stream if allowed to fish there. UCS states, "If over the course of the year, such an individual consumed 10 kg. of such fish, the dose commitment would be 454 millirems for that year." This implies that 454 millirems would be received during one year when in actuality it is spread out over fifty years. The yearly exposure if a fisherman would be able to obtain these Buttermilk Creek fish would only be 32 millirems from the 10 kg. of fish. Moreover, the model to estimate radioisotope concentrations in fish by use of reconcentration factors appears to be in error since the model predicts fish concentrations which are a factor of 2 higher than actual fish concentrations determined by analysis. Game fish samples which have been

obtained from Cattaraugus Creek contain low concentrations of radioisotopes and represent the actual exposure path to the fishermen. The resulting exposure from consumption of these fish is very low and well within all applicable limits and guidelines.

UCS has made various calculations concerning the exposure of deer on the Plant premises (p. 3.25-3.26). The calculation of a fifty year dose commitment to a deer appears to be highly questionable since the normal life span of a deer is only approximately three years.

UCS attributes activity observed in the surrounding stream prior to startup of the Plant lagoon system to an "overflow or seepage from the burial grounds" (p. 3.24-3.25). However, that activity was the result of a controlled discharge of rainwater containing trace quantities of radioactivity. This rainwater collected in the trenches during fill operations and was pumped to a holding lagoon for analysis prior to controlled release to the surface stream. Rainwater does not collect and is not transferred from the trenches after they are filled and covered. Morever, rainwater is currently cycled through the Low Level Waste Treatment facility before controlled release to the surface streams. The activity discharged from the burial site is in the millicurie range and does not represent "14% of the cesium in Buttermilk Creek and 20% of the ruthenium" as alleged by UCS.

UCS has presented greatly distorted data concerning krypton-85 (p. 3.28-3.30). The data presented appears to be from measurements taken by the USPHS on 6/14/69; however, the data quoted was measurements on the Plant site and not at the boundary of the property. The average activity was calculated by the USPHS to be 480 pCi/l for the time period between 11:45 and 14:27. The prorated twenty-four hour concentration would be 54 pCi/l in contrast to

the 680 pCi/l average estimated by UCS. The concentration would be considerably less at the site boundary. Based on meteorology data, the maximum annual exposure from krypton-85 would be 11 millirems to the nearest resident at the expanded Plant capacity.

UCS unfairly attributes measured plutonium air concentrations to the operations of our Plant (p. 3.32-3.33). The maximum plutonium concentration observed by NYSDEC was indeed .00043 pCi/m^3 of plutonium-239. However, the plutonium-238 concentration for this particular sample was .00005 pCi/m^3, not .00014 pCi/m^3, as indicated by UCS (.00014 pCi/m^3 was the maximum amount of plutonium-238 for the entire sampling program and was from a different sample). The ratio of plutonium-239 to plutonium-238 indicates that the plutonium air concentrations are attributable to fallout rather than the operations of our Plant.

In general, the UCS statement appears designed to create the impression that NFS has continuously ignored the impact of the Plant on the environment and that the planned expansion will greatly multiply the Plant's impact on the environment. Quite to the contrary, the Plant has always been operated well within applicable regulatory limits and from the outset of Plant operations, extensive data has been continuously gathered, analyzed and evaluated to determine where improvements could be made. The planned expansion is only a portion of a total modernization program that was begun in 1969 to improve Plant operations and reduce its impact on the environment. The Low Level Waste Treatment facility was the first step and UCS chose to ignore it by basing its discussion and conclusions almost exclusively on pre-1970 data.

Because of the fundamental irrelevance of the UCS statement to the proceeding, we have chosen not to draw atten-

tion away from the real issues in the proceeding by making detailed corrections to the UCS statement. We have merely attempted to alert the Commission to the unreliability of the UCS statement such that it will not form the basis for any possible erroneous conclusions regarding the NFS Plant's operating history.

Respectfully submitted,

RONALD D. LEE
Attorney for Nuclear Fuel Services, Inc.

Dated: April 16, 1973

Nuclear Fuel Services, Inc.
Suite 600
6000 Executive Boulevard
Rockville, Maryland 20852

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UNITED STATES OF AMERICA
ATOMIC ENERGY COMMISSION

In the Matter of	
AMENDMENT OF 10 CFR PART 50 — LICENSING OF PRODUCTION AND UTILIZATION FACILITIES (Environmental Effects of the Uranium Fuel Cycle)	Docket No. RM 50-3

CERTIFICATE OF SERVICE

I hereby certify that I have served copies of the attached document via first class mail, postage prepaid, upon all parties of record.

Ronald D. Lee
Attorney

Dated: April 16, 1973

Nuclear Fuel Services, Inc.
Suite 600
6000 Executive Boulevard
Rockville, Maryland 20852

WASH-1284

Environmental Survey of the Uranium Fuel Cycle

April 1974

U.S. ATOMIC ENERGY COMMISSION

FUELS and Materials

Directorate of Licensing

PREFACE

In November 1972, the "Environmental Survey of the Nuclear Fuel Cycle" was published by the Fuels and Materials staff of the USAEC Directorate of Licensing. The purpose of this document was to establish a basis for those involved in licensing proceedings to provide informed consideration to the generic question of the environmental effects associated with the uranium fuel cycle in light-water-cooled power reactors.

Comments on the Environmental Survey were solicited in the *Federal Register* notice of a rule-making hearing which was held on February 1 and 2, 1973. The purpose of the hearing was to consider possible amendments to Appendix D of 10 CFR Part 50 to factor the environmental effects of the uranium fuel cycle into the cost-benefit analysis for individual light-water-cooled nuclear power reactors. The present document takes into account the written comments that were submitted in response to the Federal Register notice as well as recommendations for improvement in presentation offered during the hearings.

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The Survey and rule-making are both limited to the uranium fuel cycle and the title of this document is being modified accordingly. The off-site environmental effects for each of the fuel cycle operations have been analysed and the data are presented in terms of the annual fuel requirements of a model 1000-MWe nuclear power reactor. Special efforts have been made to be conservative in estimating the nature and quantity of effluents ascribed to the amount of fuel needed for one year's operation of the model reactor. Where operating data were not available, approximations were made which tended to maximize the impact of the fuel cycle on the environment. All effluents, both radioactive and chemical were included. From a review of operations supplying material or utilities to each fuel cycle activity, only the generation of electrical energy for the isotope enrichment step was judged to cause significant environmental effects. The environmental effects of the coal-fired power plants used in the grids supplying the power were therefore included in the survey. These coal fired plants are the major source of gaseous effluents and use the bulk of the water for the entire fuel cycle.

The staff evaluation based upon the original edition of the Environmental Survey indicated that the environmental effects of the uranium fuel cycle that are attributable to the model reactor were small. As a result of the comments and suggestions from interested parties, additional detailed data have been included or referenced in this revised edition of the Environmental Survey. It is important to note that this added material further supports and reinforces the staff's previous conclusions.

Changes that have been incorporated in this updated edition include the following:

1. The Waste Management Section has been enlarged and expanded to include the material presented in

the testimony given during the hearings by Dr. F. K. Pittman, Director of the AEC's Division of Waste Management. Data on the proposed near term Retrievable Surface Storage Facility (RSSF) for above-grade storage of solidified high-level waste have been incorporated. Included is a reference preliminary design for the RSSF, based on existing technology, to demonstrate the validity of this concept. A brief discussion of the design with specific data relating to environmental effects, safety and accident analysis has been included.

2. The subject of "Contributions to the General Exposure" has been addressed in further detail in each basic step of the uranium fuel cycle and this separate category of analysis has been included.

   Previously, the potential exposure to the general public from minute quantities of radionuclides was considered for each step of the uranium fuel cycle. Investigation of this effect has been amplified in the present edition to include consideration of mechanisms or possible terrestrial concentrations of nuclides from the fuel cycle.

3. The reprocessing chapter has been expanded by including data and evaluations from environmental studies of the off-site environs of the Savannah River Plant and the Hanford facilities. This material has been included to provide information about the effects of the only long-term operations of fuel reprocessing plants. Data on the only commercially operated fuel reprocessing plant at West Valley, New York also have been summarized in this section to include data on this commercial plant. This report was published after the November 1972 Environmental Survey.

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Neither the previous document, "Environmental Survey of the Nuclear Fuel Cycle", nor the present document, "Environmental Survey of the Uranium Fuel Cycle", is intended to be a detailed environmental statement as defined in the National Environmental Policy Act of 1969 and Appendix D of 10 CFR 50 of the AEC's regulations. With the exception of the government-owned isotope enrichment plants and a few uranium mills in states having regulatory authority over such mills, all facilities considered in both documents have been the subject of detailed safety reviews by the staff and are operating under licenses issued by the AEC; they received individual environmental reviews under the AEC's regular policies and procedures governing such facilities. The information contained within both documents has been obtained from government and industry sources, and in some cases, from consultants. A detailed list of references, from which this information was obtained, is given at the end of each section of the survey.

The staff is grateful for the careful consideration given by all reviewers and users to the content of the Survey. Their contributions in the form of suggested improvements and detection of errors have helped to strengthen this document which serves as the technical basis for this important rulemaking decision.

TABLE OF CONTENTS

	Pages [of original]
SUMMARY	S-1 to S-33
1. Background and Purpose	S-1
2. Scope	S-1
3. Nuclear Industry Models	S-4
4. Approach to the Assessment of Environmental Considerations	S-6
5. Summary of Environmental Considerations	S-9
6. Overview of Total Nuclear Fuel Cycle	S-29
COMPONENT ENVIRONMENTAL CONSIDERATIONS:	
A. URANIUM MINING	A-1 to A-18
1. Summary	A-1
2. Description of the Uranium Mining Industry	A-5
3. Description of the Uranium Mining Model	A-6
4. Environmental Considerations	A-7
B. URANIUM MILLING	B-1 to B-25
1. Summary	B-1
2. Description of the Milling Industry	B-5
3. Description of the Uranium Milling Model Plant	B-6
4. Environmental Considerations	B-7
C. URANIUM HEXAFLUORIDE PRODUCTION	C-1 to C-26
1. Summary	C-1
2. Description of the Uranium Hexafluoride Production Industry	C-4
3. Description of the Model Uranium Hexafluoride Production Plant	C-7
4. Environmental Considerations	C-9
D. URANIUM ENRICHMENT	D-1 to D-30
1. Summary	D-1
2. Description of the Uranium Enrichment Industry	D-6
3. Description of the Model Enrichment Plant	D-12
4. Environmental Considerations	D-13

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TABLE OF CONTENTS (Continued)

	Pages [of original]
E. FUEL FABRICATION	E-1 to E-24
1. Summary	E-1
2. Description of the Fuel Fabrication Industry	E-5
3. Description of the Model Fuel Fabrication Plant	E-8
4. Environmental Considerations	E-11
F. IRRADIATED FUEL REPROCESSING	F-1 to F-40
1. Summary	F-1
2. Description of the Irradiated Fuel Reprocessing Industry	F-6
3. Environmental Studies of the Effects of Reprocessing Plants	F-15
4. Description of the Irradiated Fuel Reprocessing Model	F-20
5. Environmental Considerations	F-20
G. RADIOACTIVE WASTE MANAGEMENT	G-1 to G-21
1. Summary	G-1
2. Description of the Radioactive Waste Management Industry	G-3
3. Description of Model Waste Handling Facilities	G-7
4. Environmental Considerations	G-12
H. TRANSPORTATION	H-1 to H-26
1. Summary	H-1
2. Description of Transportation Steps and Transportation Model	H-6
3. Environmental Considerations	H-16
OVERVIEW OF THE TOTAL NUCLEAR FUEL CYCLE	O-1 to O-17
Uranium Mining	O-3
Uranium Milling	O-6
UF_6 Production	O-6
Isotopic Enrichment	O-9
Fuel Fabrication	O-11
Fuel Reprocessing	O-13
Waste Management	O-15
Transportation	O-15

SUMMARY

1. *Background and Purpose*

As part of the Federal licensing actions for individual nuclear power plants, detailed environmental statements are issued as public documents in conformance with the National Environmental Policy Act (NEPA) of 1969. These statements assess the environmental impact associated with the construction and operation of the specific nuclear power plant, as well as the transportation of radioactive materials to and from the plant. This document is an environmental survey of the nuclear fuel cycle which supports the individual nuclear power plants.

Detailed environmental reviews are carried out in the separate licensing actions for each individual fuel cycle facility involved in the handling of source material, or special nuclear material and for production facilities. Most of the facilities discussed in this environmental survey were constructed and licensed by the AEC prior to the enactment of NEPA. Accordingly detailed assessments of environmental impact have not been carried out on facilities that predated the NEPA act. It is expected, however, that detailed environmental reviews on the fuel cycle facilities processing the bulk of the nation's fuel material will be accomplished within the next few years as a result of planned modifications and expansions of existing plants, and construction of new ones. This environmental survey is not intended in any way to replace or preclude these thorough and meticulous analyses of individual plants.

2. *Scope*

This survey assesses the environmental considerations related to the currently predominant uranium fuel cycle

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for uranium dioxide (UO_2) fueled, light-water moderated and cooled nuclear power plants (LWR). In the United States, about 99% of the electric power generated from nuclear fuel incorporates this fuel cycle and a large percentage of the plants that are under consideration for construction permits or operating licenses will utilize this fuel cycle. In addition, estimates of the nuclear generation of electric power indicate that this predominance of LWR use will prevail through most of the present decade. Alternative nuclear fuel cycles involving the fuel cycle for gas-cooled reactors, plutonium recycle in the present generation of LWR power reactors, and the fast breeder cycle will be considered in future documents.

The specific components comprising the LWR supporting fuel cycle are shown in Figure S-1 and include the following:

(a) Mining uranium ore.

(b) Milling and refining ore to produce uranium concentrates (U_3O_8).

(c) Production of uranium hexafluoride (UF_6) from uranium concentrates to provide feed for isotopic enrichment.

(d) Isotopic enrichment of uranium hexafluoride to attain reactor enrichment requirements using the gaseous diffusion process.

(e) Fabrication of nuclear reactor fuel including: converting UF_6 to uranium dioxide (UO_2), pelletizing, encapsulating in rods and assembling fuel elements.

(f) Reprocessing irradiated fuel and converting uranium to UF_6 for recycle through the gaseous diffusion plant for re-enrichment.

(g) Radioactive waste management of high level and other than high level wastes, including long-term storage of wastes.

(h) Transportation activities associated with moving materials to and from each of the above operations.

As discussed earlier, the environmental considerations relating to the construction and operation of the individual nuclear power plants, including transportation of radioactive materials to and from the power plant, are considered in detailed environmental statements in the separate licensing actions for each individual facility.

The manufacturing operations supporting the nuclear fuel cycle have been reviewed and those that have been judged to be relatively remote, indirect, and less significant contributors to the environmental impact of the nuclear fuel cycle have not been included in this statement. Typical operations in this category include production of commercial reagents such as sulfuric acid, hydrogen fluoride, ammonia, nitric acid, etc.

In many instances improvements in technology are available and plans are underway for incorporating these advances into production facilities. However, the primary basis of the present survey is today's industry with only minimal allowances for advances that may be accomplished in the future. In line with Commission practice, standards and criteria relating to fuel cycle facilities are continually evaluated and modified as appropriate to reflect experience, changing technology, and expansion of the industry. Thus, future environmental evaluation should also reflect continuing changes and advances as they affect the current mode and level of operations.

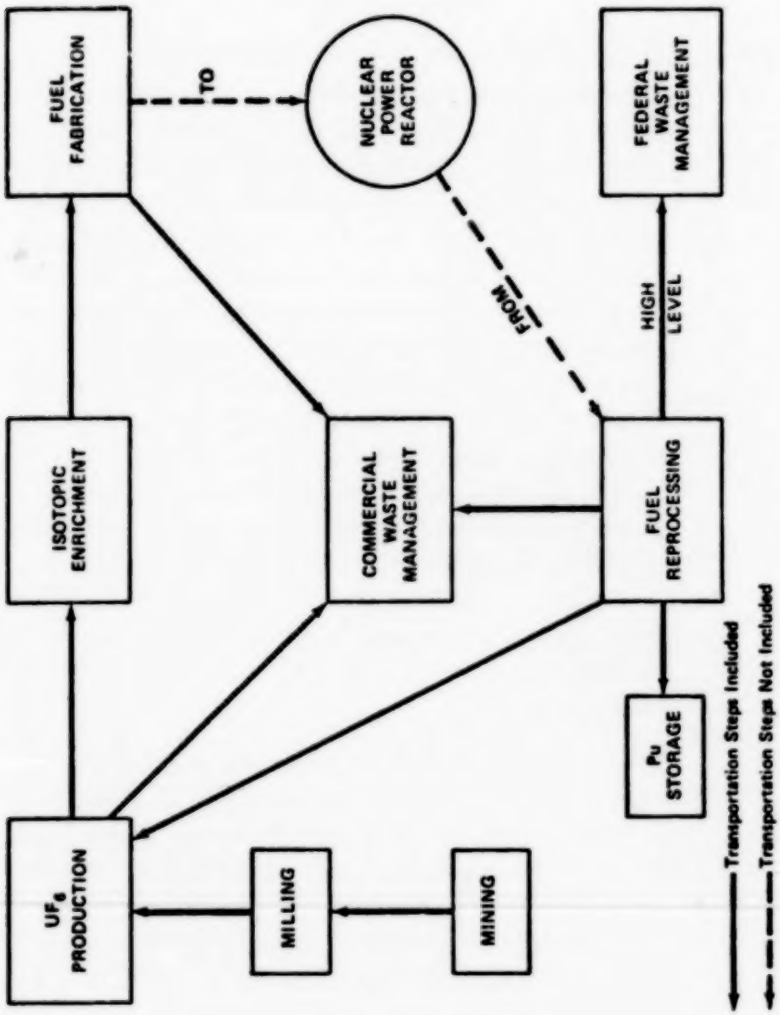

Figure S-1
URANIUM FUEL CYCLE – LIGHT WATER REACTORS
NO PLUTONIUM RECYCLE

3. *Nuclear Industry Models*

(a) Model LWR

A "model LWR" was developed to relate the environmental considerations of the supporting fuel cycle to the annual operation of a nuclear power plant using data from WASH-1139(71), Nuclear Power 1972-7000. In the development of this model, the requirements for each step of the fuel cycle have been reviewed for the current generation of 1000 MWe boiling water reactors (BWR) and pressurized water reactors (PWR). Both of these classes of LWR's utilize fuel in the form of sintered uranium dioxide pellets encapsulated in either stainless steel or zircaloy tubing. The maximum requirements in each step of the fuel cycle used to define the model LWR are listed in the first two columns of Table S-1 for both an initial core loading and an annual fuel reload together with fuel performance parameters used to define fuel requirements.

The useful life of LWR's has been estimated at between 30-40 years. For purposes of this analysis, a 30-year life has been conservatively assumed in defining the "annual fuel requirement" for the model LWR. The model LWR annual fuel requirement is defined as the sum of one initial core loading plus 29 annual reloads, averaged over the 30-year life of the plant, and is listed for each step of the fuel cycle in the third column of Table S-1. In discussing the environmental considerations of the nuclear fuel cycle steps in subsequent sections, resource use and effluent quantities have been related to this annual fuel requirement.

(b) Model Fuel Cycle Facilities

In some steps of the fuel cycle, numerous plants utilizing a wide variety of alternative processes and operations are involved. To evaluate environmental effects on a generic basis, a model fuel cycle facility for each component of the fuel cycle was defined.

TABLE S-1
CHARACTERISTICS OF MODEL LWR (1000 MWe)
MAXIMUM FUEL CYCLE REQUIREMENTS

	Initial Core	Annual Reload	Lifetime Average Annual Fuel Requirement
Irradiation level (MWD_t/MTU) x 10^{-3}	24	33	33
Fresh fuel assay (wt% U-235)	2.6	3.2	3.2
Spent fuel assay (wt% U-235)	0.76	0.84	0.84
Ore supply (MT) x 10^{-3}	332	82.5	91
Yellowcake U_3O_8 supply (MT)	665	165	182
Natural UF_6 (MT)	840	250	270
Separative work (MT SWU)	304	110	116
Enriched UF_6 (MT)	200	47	52
Enriched UO_2 (MT)	152	36	40
Fuel loading (MTU)	134	32	35

Bases
Reactor plant load factor — 80%
Enrichment tails assay — 0.25%
No plutonium recycle
Reloads include recovered uranium
Losses of 1% each in fuel fabrication and reprocessing

MT = metric ton = 2205 lbs.
MTU = metric ton uranium
MT SWU = separative work units in metric tons

Where industry has used one predominant method or one type of facility, that method or facility has been defined as the model facility. Where a single predominant operation has not been used, the mode of operation that imposes the most significant impact on the environment has been selected as the model. In some cases, where the nature of the impact from two or more modes of operation differs significantly, the aggregate operation of all plants, normalized to an appropriate annual capacity, has been selected as the model fuel cycle facility. The model fuel cycle facilities are not intended to represent particular plants. However, the models were selected to be representative of the industry and to lead to conservative or pessimistic assessments of the environmental considerations.

In the case of mining, milling, fuel fabrication, and radioactive waste management, the above approach resulted in the adoption of representative individual facilities as the model facilities. The UF_6 production model is a composite of the total industry complex of two plants that are presently in operation. The isotopic enrichment model is the total government-owned, contractor-operated complex of three plants essentially as it exists today. The reprocessing model is a composite of the total industry complex of three plants as they are planned for operation in the middle of this decade. Table S-2 gives the annual capacity of each model fuel cycle facility and relates this capacity to the annual fuel requirement of the model LWR.

The lifetime of each model fuel cycle facility was estimated to relate the land use to the model LWR

annual fuel requirement. These estimates are generally 20 years which are on the low side of the expected lifetimes, so that the resulting land use numbers are conservative.

4. *Approach to the Assessment of Environmental Considerations*

In this broad survey of environmental considerations, the nuclear fuel cycle is treated on a generic basis. This approach permits an overview of the entire industry without keying the study to particular plants and manufacturers. In order to compensate for the lack of specific detail, effluent concentrations, radiation dose rates, and human population densities appropriate to the model fuel cycle facilities are estimated in each section.

Whenever possible, the environmental considerations have been related to the annual operation of a model LWR. This has been accomplished by normalizing the land use, water use, fossil fuel use, and effluent releases (including chemical, radiological, and thermal) to the model LWR annual fuel requirement, defined above in part 3.a of this section. The summary tables in each section, and the main summary table in this section, present the environmental considerations on this normalized basis.

TABLE S-2
NUCLEAR FUEL CYCLE
CAPACITIES RELATIVE TO THE
ANNUAL FUEL REQUIREMENTS OF A MODEL LWR

	Fuel Cycle Plant Annual Capacity		Equivalent Number of Model LWR Annual Fuel Requirements
	Range	Model	
Uranium Mine (MT ore) x 10^{-3}	250–750	480	5.3
Uranium Mill (MT U_3O_8)	500–1100**	960	5.3
UF_6 Production (MTU)	5000–10,000	5000	27.5
Isotopic Enrichment (MT SWU)	6000–17,000	10,500*	90
UO_2 Fuel Fabrication (MTU)	300–1000	900	26
Spent Fuel Reprocessing (MTU)	300–1500	900	26

*Current operating level of industry and assumed model plant capacity
**Characteristic of about 70% of current facilities

It is recognized that the considerations presented in the summary tables may not adequately express the actual environmental impact of the fuel cycle. Accordingly, this information has been supplemented with concentrations and dose rates and compared with applicable and available standards.* These additional considerations are presented in the summary text in each section, as well as in the summary text in part 5 of this Section. Whereas the information presented in the summary table is normalized to the annual operation of a model LWR, it is unrealistic to express concentrations, dose rates, and postulated accident effects on this basis. Accordingly, these considerations are based upon the operation of the model fuel cycle facilities at the design throughput (from Table S-2).

*Most commonly used Federal, State and international standards were utilized for both radiological and non-radiological effluents.

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A detailed environmental review of an industrial process effluents involves the consideration of three components. These are (1) a source term or rate of effluent release, (2) a dilution term, or dispersion of the effluent throughout the medium under consideration, and (3) a population term, giving the distribution of human beings or biota affected by the effluent. To evaluate environmental impact, these factors must be combined.

Estimates of effluent concentrations and radiation doses at the site boundaries of the model fuel cycle facilities are based upon experimental data or calculated values. Where measurements are available, these data have been used. In most cases, however, it has been necessary to calculate these quantities, based upon estimated release rates and a model for dispersion. For the fuel reprocessing step, detailed analyses have been made of atmospheric dispersion in conjunction with the NEPA review and the preparation of the detailed environmental statement for specific plants. Therefore for that step in the nuclear fuel cycle the discussion is based upon actual meteorological conditions at the specific sites. For other components of the fuel cycle, for which no such data were available, the model utilizes x/Q values which are 1/10 of those given in AEC Safety Guide No. 3, as applicable for the model sites.

Where measured or estimated concentrations of chemicals in surface waters were available, these concentrations have been compared with the recommended criteria contained in the Water Quality Criteria "Green Book."** This volume represents the most comprehensive document on water quality requirements, and is used as a basic reference by agencies engaged in water quality standards setting activities. The recommended

**Water Quality Criteria; Report of the National Technical Advisory Committee to the Secretary of the Interior; U. S. Federal Water Pollution Control Administration; Washington, D. C., April 1, 1968.

criteria are for surface water which is to be subjected to normal water supply treatment prior to consumption as drinking water.

Airborne effluent concentrations have been compared with current EPA National Secondary Ambient Air Quality Standards,* where these are available. The secondary standards are designed to protect the public welfare from any known or anticipated adverse effects associated with the presence of air pollutants in the ambient air. For sulfur oxides, the secondary standard is 0.02 ppm, annual arithmetic mean, and for nitrogen dioxide it is 0.05 ppm annual arithmetic mean.

It is important to note that the discussion of environmental considerations in this document is confined to off-site effects; occupational health and safety of on-site workers are given major consideration by the AEC in detailed safety licensing reviews for individual facilities.

5. *Summary of Environmental Considerations*

The principal environmental considerations for each component of the nuclear fuel cycle, and the aggregate considerations, normalized to the annual fuel requirement of a 1000 MWe model LWR, are summarized for the nuclear fuel cycle in Table S-3. Table S-3A similarly summarizes the consideration for each step in the nuclear fuel cycle.

In the document, land commitments are described as "temporary" or "permanent." A "temporary" land commitment is a commitment for the life of the plant, or succeeding plants. On the abandonment or decommissioning of the plant, such committed land can be

*National Primary and Secondary Ambient Air Quality Standards, published by the Environmental Protection Agency, Federal Register, Volume 36, Number 84, April 30, 1971.

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TABLE S-3

Summary of Environmental Considerations for Uranium Fuel Cycle
(Normalized to Model LWR Annual Fuel Requirement)

	Total	Maximum Effect per Annual Fuel Requirement of Model 1000 MWe LWR
Natural Resource Use		
Land (acres)		
Temporarily committed	63	
Undisturbed area	45	
Disturbed area	18	Equivalent to 90 MWe coal-fired power plant
Permanently committed	4.6	
Overburden moved (millions of MT)	2.7	Equivalent to 90 MWe coal-fired power plant
Water (millions of gallons)		
Discharged to air	156	~2% model 1000 MWe LWR with cooling tower
Discharged to water bodies	11,040	
Discharged to ground	123	
Total	11,319	<4% of model 1000 MWe LWR with once-through cooling
Fossil Fuel		
Electrical energy (thousands of MW-hr.)	317	<5% of model 1000 MWe LWR output
Equivalent coal (thousands of MT)	115	Equivalent to the consumption of a 45 MWe coal-fired power plant
Natural gas (millions of scf)	92	<0.2% of model 1000 MWe energy output
Effluents — Chemical (MT)		
[1]Gases (including entrainment)		
SO_x	4,400	
[2]NO_x	1,177	Equivalent to emissions from 45 MWe coal-fired plant for a year.
Hydrocarbons	13.9	

[1]Estimated effluents based upon combustion of equivalent coal for power generation.

[2]1.2% from natural gas use and process.

TABLE S-3 (Cont.)

Summary of Environmental Considerations for Uranium Fuel Cycle
(Normalized to Model LWR Annual Fuel Requirement)

	Total	Maximum Effect per Annual Fuel Requirement of Model 1000 MWe LWR
Effluents — Chemical (MT) (Cont.)		
CO	28.7	
Particulates	1,156	
Other Gases		
F^-	0.72	Principally from UF_6 production enrichment and reprocessing. Concentration within range of state standards — below level that has effects on human health.
Liquids		From enrichment, fuel fabrication, and reprocessing steps. Components that constitute a potential for adverse environmental effect are present in dilute concentrations and receive additional dilution by receiving bodies of water to levels below permissible standards. The constituents that require dilution and the flow of dilution water are: NH_3 — 600 cfs; NO_3 — 20 cfs; fluoride — 70 cfs
$SO_4^=$	10.3	
NO_3^-	26.7	
Fluoride	12.9	
Ca^{++}	5.4	
Cl^-	8.6	
Na	16.9	
NH_3	11.5	
Fe	0.4	
Tailings Solutions (thousands of MT)	240	From mills only — no significant effluents to environment.
Solids	91,000	Principally from mills — no significant effluents to environment.
Effluents — Radiological (curies)		
Gases (including entrainment)		
Rn-222	75	Principally from mills — Maximum annual dose rate <4% of average natural background within 5 miles of mill. Results in 0.06 man-rem per annual fuel requirement.
Ra-226	0.02	
Th-230	0.02	
Uranium	.032	

TABLE S-3 (Cont.)

Summary of Environmental Considerations for Uranium Fuel Cycle
(Normalized to Model LWR Annual Fuel Requirement)

	Total	Maximum Effect per Annual Fuel Requirement of Model 1000 MWe LWR
Effluents — Radiological (curies) (Cont.)		Principally from fuel reprocessing plants — Whole body dose is 4.4 man-rem per annual fuel requirements for population within 50-mile radius. This is <0.005% of average natural background dose to this population. Release from Federal Waste Repository of 0.005 Ci/yr has been included in fission products and transuranics total.
Tritium (thousand)	16.7	
Kr-85 (thousands)	350	
I-129	0.0024	
I-131	0.024	
Fission Products & Transuranics	1.01	
Liquids		
Uranium & daughters	2.1	Principally from milling — included in tailings liquor and returned to ground — no effluents; therefore, no effect on environment.
Ra-226	.0034	From UF_6 production-concentration 5% of 10 CFR 20 for total processing of 27.5[6] model LWR annual fuel requirements.
Th-230	.0015	
Th-234	0.01	From fuel fabrication plants — concentration 10% of 10 CFR 20 for total processing 26 annual fuel requirements for model LWR.
Ru-106	0.15*	From reprocessing plants — maximum concentration 4% of 10 CFR 20 for total reprocessing of 26 annual fuel requirements for model LWR.
Tritium (thousands)	2.5	
Solids (buried)		
Other than high level	601	All except 1 Ci comes from mills — included in tailings returned to ground — no significant effluent to the environment. 1 Ci from conversion and fuel fabrication is buried.
Thermal (billions)	3,360	<7% of model 1000 MWe LWR.
Transportation (man-rem)		
Exposure of workers and general public	0.334	

*Cs-137 (.075 Ci/AFR) and Sr-90 (.004 Ci/AFR) are also emitted.

TABLE S-3A

Summary of Environmental Considerations for Nuclear Fuel Cycle

Normalized to Model LWR Annual Fuel Requirement

Natural Resource Use	A Mining	B Milling	C UF_6 Prod.	D Enrichment	E Fuel Fab.	F Reprocessing	G Waste Management	H Transportation	Total
Land (Acres)									
Temporarily Committed	55	0.5	2.5	0.8	0.2	3.9	—	—	63
Undisturbed Area	38	0.2	2.3	0.6	0.16	3.7	—	—	45
Disturbed Area	17	0.3	0.2	0.2	0.04	0.2	—	—	18
Permanently Committed	2	2.4	0.02	0.0	0.0	0.03	0.2	—	4.6
Overburden moved (millions of MT)	2.7	—	—	—	—	—	—	—	2.7
Water (millions of gal.)									
Discharged to air	—	65	3.3	84	—	4.0	0.13	—	156
Discharged to water bodies	—	—	23.0	11,006	5.2	6.0	0.13	—	11,040
Discharged to ground	123	—	—	—	—	—	—	—	123
Total Water	123	65	26.3	11,090	5.2	10.0	0.26	—	11,319
Fossil Fuel									
Electrical energy (thousand MW-hr.)	0.25	2.70	1.70	310	1.7	0.45	.0077	—	317
Equivalent Coal (thousand MT)	0.09	0.97	0.62	113	0.62	0.16	.003	—	115
Natural Gas (million scf)	—	68.5	20.0	—	3.6	—	—	—	92

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TABLE S-3A (Cont.)

Summary of Environmental Considerations for Nuclear Fuel Cycle

Normalized to Model LWR Annual Fuel Requirement

	A	B	C	D	E	F	G	H	
Natural Resource Use	Mining	Milling	UF_6 Prod.	Enrich-ment	Fuel Fab.	Repro-cessing	Waste Manage-ment	Transper-tation	Total
Effluents									
Chemical (MT)									
Gases (MT)									
SO_x	8.5	37.0	29.0	4,300	23	6.2	—	—	4,400
NO_x	5.0	15.9	10.0(3)	1,130	6	7.1(4)	—	2.6	1,177
Hydrocarbons	0.3	1.3	0.8(2)	11	0.06	0.02	—	—	13.5
CO	0.02	0.3	0.2	28	0.15	0.04	—	—	28.7
Particulates	—	9.7	7.6	1,130	6	1.6	—	—	1,156
Other Gases									
F−	—	—	0.11	0.5	0.005	0.11	—	—	0.72
Liquids									
SO_4=	—	—	4.5	5.4	—	0.4	—	—	10.3
NO_3	—	—	0.1	2.7	23	0.9	—	—	26.7
Fluoride	—	—	8.8	—	4.1	—	—	—	12.9
Ca−	—	—	—	5.4	—	—	—	—	5.4
Cl+	—	—	0.2	8.2	—	0.2	—	—	8.6
Na	—	—	3.9(5)	8.2	—	5.3	—	—	16.9
NH_3	—	—	—	—	10.0	—	—	—	11.5
Tailings Solutions (thousands)	—	240	1.5	—	—	—	—	—	240
Fe	—	—	—	0.4	—	—	—	—	0.4
Solids	—	91,000	40	—	26	—	—	—	91,000

(1) Estimated Effluents Based Upon Combustion of Equivalent Coal for Power Generation
(2) Combined Effluents from Combustion of Coal and Natural Gas and process tankage; contains 0.2 MT of Hexane
(3) 25% from natural gas use
(4) 77% from process
(5) Contains about 80% Potassium

TABLE S-3A (Cont.)

Summary of Environmental Considerations for Nuclear Fuel Cycle

Normalized to Model LWR Annual Fuel Requirement

	A	B	C	D	E	F	G	H	
Natural Resource Use	**Mining**	**Milling**	**UF_6 Prod.**	**Enrich-ment**	**Fuel Fab.**	**Repro-cessing**	**Waste Manage-ment**	**Transpor-tation**	**Total**
Effluents (cont.)									
Radiological (curies)									
Gases (including entrainment)									
Rn-222	—	74.5	—	—	—	—	—	—	74.5
Ra-226	—	0.02	—	—	—	—	—	—	0.02
Tn-230	—	0.02	—	—	—	—	—	—	0.02
Uranium	—	0.03	0.0015	0.002	0.0002	—	—	—	0.032
Tritium (thousands)	—	—	—	—	—	16.7	—	—	16.7
Kr-85 (thousands)	—	—	—	—	—	350	—	—	350
I-129	—	—	—	—	—	0.0024	—	—	0.0024
I-131	—	—	—	—	—	0.024	—	—	0.024
Fission Products	—	—	—	—	—	1.0	—	—	1.0
Transuranics	—	—	—	—	—	0.004	—	—	0.004
Liquids									
Uranium & Daughters	—	2	0.044	0.02	0.02	—	—	—	2.1
Ra-226	—	—	0.0034	—	—	—	—	—	0.0034
Th-230	—	—	0.0015	—	—	—	—	—	0.0015
Th-234	—	—	—	—	0.01	—	—	—	0.01
Tritium (thousands)	—	—	—	—	—	2.5	—	—	2.5
Ru-106	—	—	—	—	—	0.15	—	—	0.15*
Solids (buried)									
Other than high level	—	600	0.86	—	0.23	—	—	—	601
Thermal (billions of Btu)	—	69	20	3200	9	61	1.0	0.03	3,360

*Cs-137 (0-075 Ci/AFR) and Sr-90 (0.004 Ci/AFR) are also emitted.

used for any purpose. "Permanent" commitments of land represent land that may not be released for use after plant shutdown and decommissioning.

(a) Use of Natural Resources

(1) Land

The temporary land commitment amounts to 63 acres per annual fuel requirement for the model LWR. More than 70% of this land is an undisturbed area or which may be withdrawn by fencing from active use by human habitation. The fencing also restricts migration of large animals. Approximately 18 acres are transformed from their original state by the construction of facilities. Less than 5 acres of land are permanently committed to the production of the annual fuel requirement for a model LWR.

At any time, the total temporary land commitment required by the fuel cycle to support a 1000 MWe LWR is about 750 acres. The total permanent land commitment, assuming a 30-year reactor life, is about 140 acres.

To cast the land requirements into further perspective, a coal-fired power plant of 1000 MWe capacity requires the disturbance of approximately 200 acres per year for strip mining alone. The disturbed area for the nuclear fuel cycle amounts to approximately 18 acres per annual fuel requirement of a model LWR, which is less than 10% of the equivalent annual coal mining land commitment or equivalent to a 90 MWe coal-fired power plant fuel requirement.

(2) Water

Water is used in the nuclear fuel cycle both as a coolant and for process requirements. Water uses have been grouped into three categories based upon the method of return of the water to the biosphere. Water is evaporated into the air, discharged into water bodies or is returned to the ground.

The largest quantity of water involved is the 11 billion gallons required to remove the waste heat from the power stations supplying electrical energy to the enrichment step of the nuclear fuel cycle in the production of an annual fuel requirement. Assuming once-through cooling at these power stations, all of this water is returned to surface water bodies. An additional 319 million gallons of water are directly involved at the fuel cycle plants for cooling, process, and dewatering requirements, totaling 11.3 billion gallons of water moved in producing the annual fuel requirement for the model LWR.

In order to remove the waste heat from a 1000 MWe nuclear power plant on a once-through basis, approximately 300-400 billion gallons of water are pumped annually. Thus, the total demand for water in the components of the nuclear fuel cycle constitutes less than 4% of the water requirement of a 1000 MWe LWR.

The largest single direct dissipation of water by evaporation in the nuclear fuel cycle is for process cooling in the enrichment step. The

gaseous diffusion plants evaporate approximately 84 million gallons of water to the atmosphere per model LWR annual fuel requirement. This constitutes approximately 54% of the 156 million gallons of water discharged to the atmosphere in the nuclear fuel cycle. As a point of reference, a 1000 MWe LWR utilizing cooling towers would evaporate approximately 7 billion gallons of water per year to the atmosphere or more than 40 times the evaporative use of water by the nuclear fuel cycle to produce the fuel for a year's operation.

The requirement for uranium mine drainage moves over 120 million gallons of water per model LWR annual fuel requirement. However, minimum depletion is involved, since the water is pumped from the bottom of the mine pit to the ground surface for return to ground water at some other location with some being returned to the atmosphere by evaporation.

(3) Other

The uranium enrichment component of the nuclear fuel cycle requires over 98% of the electrical energy required by the fuel cycle. The total electrical requirements are 317 thousand MW-hr for the annual fuel requirement of a model LWR. A 1000 MWe LWR would produce 7 million MW-hr in annual operation at a load factor of 80%. Thus the electrical requirements of the nuclear fuel cycle to produce fuel for this reactor are less than 5% of the energy produced by the reactor in a year's operation.

At present most of the electricity generated in the United States is produced in plants that burn fossil fuels. Assuming that coal comprises the bulk of fossil fuel utilization, the electrical energy requirements of the fuel cycle correspond to the consumption of 115 thousand MT of coal. A 1000 MWe coal-fired station consumes approximately 2540 thousand MT of coal annually. Thus, the nuclear fuel cycle for a model 1000 MWe LWR consumes about the quantity of coal required for a 45 MWe fossil-fueled plant.

Additionally, approximately 90 million scf of natural gas are consumed for process heat, most of which is used in the milling operation. This quantity of natural gas could be used to generate roughly 9,000 MW-hr of electricity, which is less than 0.2% of annual output of the model LWR.

(b) Effluents

(1) Chemical

(i) Gaseous

At present, most of the power plants that supply electricity to the fuel cycle operations burn coal. Consequently, the combustion products of coal comprise nearly all of the airborne chemical effluents attributable to the fuel cycle and approximate the effects from the operation of a 45 MWe coal-fired power plant for a year. The main contributor to these gaseous effluents is the uranium enrichment step,

which consumes over 98% of the electrical energy required by the fuel cycle. The existing plants draw power from the grids of large utilities; thus, no single power supply source can be identified with the gaseous effluents. To the extent that power is supplied by nuclear power plants, the total quantity of sulfur dioxide, nitrogen oxides, hydrocarbons, carbon monoxide, and airborne particulates would be greatly reduced.

Fluorine is introduced into the fuel cycle during the UF_6 production step and is removed from the fuel material in the fuel fabrication step. As a result, fluorine becomes an airborne effluent from several steps of the nuclear fuel cycle. Although most of the fluorine gaseous wastes are effectively removed by scrubber treatment systems, approximately 0.7 MT per model LWR annual fuel requirement is released to the environment as an airborne contaminant. To put this quantity into perspective, the estimated fluoride emissions from four major industries are given in Table S-4. Assuming a nuclear power generation industry of 140 model LWR's by 1980, approximately 100 MT of gaseous fluorides would be released annually by the entire nuclear industry at that time. This constitutes about 0.1% of the total annual quantity of fluoride emissions from the total of the industries noted in Table S-4.

Despite the trivial nature of this effluent in comparison with other major industries, the airborne fluoride release from the nuclear fuel cycle could constitute a potential for adverse environmental impact. Measurements or calculations of airborne fluoride concentrations at the site boundaries of specific plants fall within the range of 0.005-2.0 $\mu g/m^3$. For

TABLE S-4

ESTIMATED FLUORIDE EMISSIONS FROM MAJOR U. S. INDUSTRIES

Source	Emissions MT/yr.
Phosphate Industry (principally fertilizer manufacture)	17,000
Aluminum Manufacture	15,000
Steel Manufacture	39,000
Brick, tile, glass manufacture	19,000
TOTAL	90,000

perspective, these concentrations are well below the level of observed adverse effects on human health, and they span the range of existing state standards.* State standards are used for comparison because there are no applicable Federal Standards.

At uranium mills and UF_6 production plant sites, the combustion of natural gas

*State of Washington: 0.5 $\mu g/m^3$
State of Pennsylvania: 5.0 $\mu g/m^3$

for process heat is a source of nitrogen oxide release to the environment. Dispersion calculations indicate that annual mean NO_x concentrations are within the EPA air quality standards of 100 $\mu g/m^3$. That standard, according to the Environmental Protection Agency, is adequate to protect the public welfare from any known or anticipated adverse effects associated with the presence of oxides of nitrogen in ambient air.

(ii) Liquid

The largest quantity of liquid effluents, 240 thousand of waste solutions per annual fuel requirement, contains sulfuric acid and other spent chemicals from the milling processes. This waste liquor, however, is discharged to the tailings pond, and since it does not normally contaminate unrestricted ground or surface bodies of water, it does not actually become an effluent stream.

Significant quantities of a number of chemicals are discharged in liquid effluents from the UF_6 conversion, enrichment, fuel fabrication and reprocessing steps. The UF_6 conversion plant releases sulfates, fluorides, chlorides, sodium and potassium, ammonia, and iron in its liquid waste. After mixing in the adjacent river, the calculated increase in river water impurities does not exceed 4% under average conditions at the dry process plant. Meas-

ured concentrations of fluoride and nitrate downstream of the wet process plant show these concentration to be below surface water standards.

The concentrations of fluorides, nitrates, and ammonia contained in the liquid waste streams from the model fuel fabrication plant are a possible source of adverse environmental effect. Dilution of these constituents by the receiving body of water by 1-3 orders of magnitude may be required to achieve drinking water source quality, depending upon the flow rate of the receiving body of water, its upstream quality and its downstream use. Efforts are in progress to minimize these releases from existing plants.

The liquid effluent quantities from enrichment appear large but generally the chemicals do not constitute a potential for adverse environmental effect and are present at or near drinking water concentrations. The enrichment step contributes the largest total quantity of liquid contaminants, but the concentrations of potential contaminants in the effluent streams are generally within the range of permissible standards.* Additional dilution by about 700-1000 times by the receiving body of water decreases the concentrations well below acceptable levels.

Treatment facilities are being planned to reduce the release of hexavalent chro-

*Water Quality Criteria, U. S. Department of the Interior, April 1, 1968.

mium. The iron concentration, another restrictive species, is diluted to approximately 0.003 ppm in the receiving bodies of water, two orders of magnitude below the recommended criteria.

Fluoride and nitrate wastes are contained in the liquid effluents from UF_6 production plants, while nitrates, sodium, chloride, and sulfates are the principal contaminants in liquid effluents from fuel reprocessing operations. In both cases, dilution in receiving rivers is adequate to reduce the incremental increase in concentration of these species to fractions of a ppm, and at least an order of magnitude below Water Quality Criteria, U. S. Department of the Interior, April 1, 1968.

(iii) Solid

The greatest bulk of solid materials is generated in the open pit mining and milling operations. The barren rock and earth overburden produced by the mine temporarily constitute a waste material, but are essentially returned to the barren mine as backfill and have not been considered as an effluent. The tailings from the mill are composed primarily of sandstone and clays and constitute the major quantity (91,000 MT) of solid waste from the fuel cycle. They are pumped as a slurry to the tailings pond, where they are permanently stored as solids in a chemical form similar to their original

condition, but containing slightly less radioactivity, since uranium has been removed.

The 50 tons of ash generated by the hydrofluor UF_6 production process consists of nonvolatile fluorides. Since the ash residue contains traces of radionuclides, it is packaged and shipped for burial at a licensed commercial disposal site and thus does not become an effluent to the environment.

Most of the fluorine added to the fuel cycle during the UF_6 production step is removed and precipitated as CaF_2 in the fuel fabrication step. The 26 MT of precipitated calcium fluoride per annual fuel requirement, occupying a volume of approximately 11 cubic yards, may be buried in trenches on the site of the fuel fabrication plant and covered with backfill.

(2) Radiological

(i) Gaseous

The most significant gaseous radiological release from the fuel cycle derives from the fuel reprocessing step. Nearly all of the krypton-85, most of the tritium (in the model plant, 13% of the tritium is released directly to the watershed) minute quantities of radioiodine, other fission products, and transuranic isotopes created in the nuclear reactor fuel are released as particulates to the atmosphere

from the reprocessing plant operations. However, the estimated annual radiation doses from the model plant to an individual at the site boundary are approximately 2.5 mrem to the whole body, 4.2 mrem to the bone, 6.3 mrem to the thyroid, and 9.25 mrem to the outer layer of skin.

The long-term equilibrium buildup of Kr-85 in the atmosphere, due to one model 1000 MWe LWR, will eventually contribute approximately 120 man-rem annual whole body exposure to the entire population of the northern hemisphere (4 billion people). For comparison, the annual population dose to the same number of people from natural background radiation is approximately 500 million man-rem.

Tritium released from reactor fuel reprocessing can also increase the exposure of the world population. Dose to the U.S. population from the inventory of world wide reactor produced tritium is estimated to be 0.0006 millirem/yr.

Small quantities of uranium and its daughters are released to the atmosphere in several steps of the fuel cycle. Data are unavailable for the total quantity of activity released from the mining operation, but attempts to measure radon concentrations in an open-pit mine revealed no significant alpha concentrations. Esti-

mates of the site boundary concentration of thorium-230 from the model mill are approximately 15% of the 10 CFR 20 limit. In all other cases, the concentrations of uranium and its daughters are estimated to range from 1-4% of the 10 CFR 20 limits for unrestricted areas.

(ii) Liquid

In the fuel reprocessing for a model LWR annual fuel requirement, approximately 2500 curies of tritium, 0.15 curies of ruthenium-106, .075 curies of Cs-137, and .004 curies of Sr-90 are released in the liquid effluent from the model plant.

Small quantities of uranium and its daughters are released in liquid effluents from each step of the fuel cycle. In the mining operation, several curies of activity are dissolved and suspended in the mine drainage water and returned to the ground. At the mill, approximately 2 curies of activity per annual fuel requirement are discharged in the tailings solution and thus are returned to the ground. In the remaining components of the fuel cycle, small quantities of radioactivity are released to receiving bodies of water. Offsite measurements in the vicinity of a UF_6 production plant indicate that annual mean radionuclide concentrations are maintained below 5% of the 10 CFR 20 limits. Estimates of the concentrations of radionuclides in effluent streams

from enrichment and fuel fabrication plants indicate that concentrations are below 1% and 10% respectively of the 10 CFR 20 limits before dilution in receiving waters.

(iii) Solid

The most significant solid radiological waste consists of the fission products separated from the spent fuel of an annual fuel requirement in the reprocessing operation. These high level wastes will be stored onsite for a maximum of 10 yrs., and will ultimately be shipped, probably by rail, to a Retrievable Surface Storage Facility (RSSF). The RSSF will be established to store and manage high level solid wastes under constant surveillance for up to 100 years, or until such time as a more permanent Federal repository can be established. The facility will be designed to prevent the release of significant amounts of radioactive material to the environment under all credible environmental conditions and human actions. Therefore, such wastes will not be released as effluents to the environment.

The fuel element hulls and other fuel element parts contaminated with trace quantities of uranium, transuranics and fission products will be buried onsite at the reprocessing facility in a retrievable form and may be eventually shipped to the RSSF. Other low specific activity ma-

terial, such as laboratory wastes, may be buried onsite or at a commercial burial ground.

Other than high activity solid wastes from UF_6 production, fuel fabrication, and reprocessing facilities amounting to a few curies per annual fuel requirement are packaged and shipped by truck to a licensed commercial burial site. The geological and hydrological characteristics of these burial sites are such that little or no migration of radioactive material from the site is postulated. The burial sites are enclosed by fences and access is controlled.

The solid waste tailings from the milling operation, which contain most of the uranium daughter products originally in the ore (approximately 600 curies per annual fuel requirement), are slurried in the waste milling solutions. The solutions are pumped to the tailings retention pond and consequently the activity is contained onsite.

The public is exposed to a small amount of direct radiation exposure during the normal shipment of solid wastes. Approximately 600,000 people along the route of travel will receive a population dose of roughly 0.036 man-rem during the rail shipment of high level solid wastes from the fuel reprocessing plant site to the Federal storage facility. The

population dose to approximately 200,000 people from the truck shipments of low specific activity solid wastes to commercial burial sites consists of roughly 0.011 man-rem. These dosages constitute less than 0.000006% of the natural background radiation.

(3) Thermal

Approximately 3.4 x 10^{12} Btu of waste heat are discharged to the biosphere in the production of a model LWR annual fuel requirement. For purposes of comparison, the waste heat from the annual operation of a 1000 MWe model LWR is approximately 50 x 10^{12} Btu. Thus, the thermal effluents from the supporting fuel cycle constitute less than 7% of the thermal release from the model LWR.

About 95% of the waste heat from the supporting fuel cycle originates in the uranium enrichment step. In this step, 1.6 x 10^{12} Btu are discharged to water bodies at the supporting electric power stations (assuming that the power stations that supply electricity to the gaseous diffusion plants utilize once-through cooling), 0.5 x 10^{12} Btu are discharged to the atmosphere through the stack at the electric power stations, and 1.1 x 10^{12} Btu are discharged to the atmosphere at the gaseous diffusion plants from cooling towers.

The operation of cooling towers leads to local misting and fogging under certain meteorological conditions. At the gaseous diffusion plants, however, this effect does not extend

beyond the site boundaries. The impact of the thermal discharge to water bodies is difficult to estimate, since the power is drawn from the grids of large utility complexes and the heat is dissipated to a number of receiving bodies of water.

(c) Accident Considerations

The history of the nuclear fuel cycle to date indicates that accidents in fuel cycle facilities which could result in significant effects on the offsite environment are highly improbable. This record of the commercial nuclear fuel cycle industry has been accomplished by the consideration of safety as a controlling factor in all its functions. Each applicant in his license application is required to analyze potential conditions that could result in the release of radioactivity beyond the plant confines and by proper design, construction and operation to minimize such releases. As a further assurance, the Regulatory Staff performs a detailed independent safety evaluation of each commercial fuel cycle facility which includes at least the following elements:

(1) *Site Analysis* — Site conditions such as geography, meteorology, hydrology, and seismology are reviewed; in addition, maximum natural phenomena criteria are considered in the case of plutonium plants and reprocessing plants.

(2) *Process Evaluation* — The process flow sheet is reviewed in detail to identify potential effluents and safety problems during normal and abnormal operations.

(3) *Structures and Systems* — The building itself, including modules, layouts, etc., is reviewed for safety, emergency escape, limiting the spread of contamination and prevention and control of fires.

Systems — Ventilation, air cleaning, waste treatment, safety instrumentation and monitoring systems are analyzed for suitability under normal and abnormal conditions.

Equipment — The adequacy and reliability of the process and utility equipment are reviewed including the Quality Assurance (QA) on design, construction, installation, operation, and maintenance. For plutonium conversion and fabrication facilities and for reprocessing plants, Appendix B of 10 CFR 50 covering QA requirements is a requirement.

(4) *Radiation Safety and Nuclear Safety Programs* — The review includes contamination control considerations, ventilation system performance, exposure assessment for workers and control of such exposure. Effluents and effluent treatment and monitoring systems for both liquid and gaseous streams leaving the plant are evaluated. Accident analyses that include consideration of criticality, radiation safety, and nonradiation safety problems are performed. In the fuel cycle plants handling special nuclear material, both liquid and solid systems are evaluated for criticality safety.

(5) *Procedures* — The licensee is required to have detailed operating and maintenance procedures. The training and testing programs for

operators are reviewed. Particular attention is given to fuel reprocessing plant operators who are tested and licensed by the AEC. The licensee must provide a corporate hazard committee or some similar organization that has responsibility for review of new processes and plant changes. Safety audits of operations are required to be made by the licensee who must report the results of these audits.

Emergency plans are submitted by the licensee and are reviewed for adequacy and detailed coverage. Emergency plans are required for all the special nuclear material plants and for fuel reprocessing plants in accordance with licensing conditions or Appendix E of 10 CFR 50.

(6) *Materials and Plant Protection Evaluation* —

In addition to the licensing functions of health and safety evaluation is the safeguards program of the applicant for the control of special nuclear material and the means by which he intends to protect those materials against theft, diversion, or sabotage.

In addition to requirements for care in design, construction, and operations of nuclear fuel cycle facilities, each licensee is required to report incidents to the cognizant AEC Regulatory Operations office which either have or threaten to cause any of the following types of events:

(i) Radiation exposure of individuals beyond stated limits.

(ii) Release of radioactive materials in daily averaged concentrations of more than 500 times limits specified in 10 CFR 20, Appendix B, Table II.

(iii) A loss of operations of any affected facility for a period of greater than one day.

(iv) Damage to property of over $1000.

The information in these reports is used as a basis for corrective action to prevent similar events from occurring in existing plants and is taken into account in the licensing actions on new or modified facilities of a similar nature. Such information is also evaluated to determine the need for new or modified standards and criteria.

The effectiveness of these measures to date is borne out by the fact that the incidents which have occurred in fuel cycle facilities in this country to date have neither resulted in significant injury nor endangered the health of any individual in the general public. Nevertheless, for each licensed operation of the fuel cycle, a series of potential accidents with environmental effects judged to range from trivial to serious have been postulated and evaluated in the safety analysis that is performed before the individual facility license is issued. Records to date indicate few if any of the routine type accidents involving special nuclear material have had any measurable effects on the environment. Thus, the review of accidents for this statement has been con-

centrated upon the most serious accidents that either have occurred or realistically can be postulated. The estimated radiological environmental effects of the most significant of these accidents are summarized in Table S-5 which lists the resulting calculated radiation exposure in unrestricted areas.

No criticality incident has occurred in the United States during the processing of low enrichment uranium.* Equipment design, system parameters, and administrative procedures in fuel cycle facilities handling enriched uranium require that two independent errors be necessary for the occurrence of an accidental criticality, reducing the probability of an accidental criticality event to an extremely low value. The resulting dose from such a highly unlikely criticality incident is considerably greater than the annual dose from background radiation; however, it is lower than the maximum annual dose permitted by 10 CFR 20 for occupational exposure.

*Although no such incident in the rest of the world is known to us, our information may be incomplete.

TABLE S-5

SUMMARY OF OFF-SITE EXPOSURES FROM POSTULATED ACCIDENTS

Accident	Fuel Cycle Component	Calculated Off-Site Exposure (rem)	Principal Affected Organ
Criticality Incident*	Fabrication	6.6	Thyroid
		1.3	Whole-body
UF_6 Cylinder Rupture	UF_6 Production Enrichment	0.4	Bone
UF_6 Cylinder Rupture	Fabrication	0.1	Bone
Criticality Incident*	Enrichment	0.061	Thyroid
		0.08	External Neutron and Gamma (Whole-body)
Criticality Incident	Reprocessing	0.04	Thyroid
UF_6 Loadout System Leak	Reprocessing	0.01	Bone
Storage Pool Cooler Leak	Reprocessing	0.01	Bone

A rupture or valve failure in a UF_6 cylinder is unlikely, but incidents of this nature have occurred in the past. An accident of this type could occur under varying conditions at a UF_6 plant, enrichment plant, or fuel fabrication facility. In estimating the offsite doses from this postulated accident, assumptions were made regarding the quantity released, the effectiveness of filters, and meteorological conditions. The calculated radiation doses are higher than the average annual dose from natural background radiation but are within the limits of 10 CFR 20 for unrestricted areas. The postulated accident at the UF_6

*Very improbable, has never occurred with low enriched uranium.

plant results in the highest offsite effects since it is assumed that the UF_6 cylinder malfunction occurs out-of-doors. Additionally, the fluoride release associated with the accident could result in some localized injury to plant life.

The accidents which were hypothesized for the mining, milling and waste management components of the fuel cycle do not result in significant offsite releases, or at worst entail limited decontamination efforts in the immediate vicinity of the site. The Federal facility for the interim storage of high level wastes will be designed to withstand all natural forces and man-created accidents so that there will be no significant release of radioactive materials to the environment outside of the facility.

It is estimated that 2.8 accidents involving truck shipments of non-enriched fuel cycle material could occur per thirty year lifetime of a model LWR. The low specific activity of the materials would limit the effects of a breach of containment to minor consequences. The likelihood of a criticality incident occurring during a truck shipment of fissile material is estimated to be infinitesimally small. Finally, it is estimated that 0.05 rail accidents involving the shipment of high level wastes to a Federal storage facility might occur per thirty year lifetime of a model LWR. Containers for high level waste must be designed and constructed to withstand accidents likely to be encountered in transport.

6. *Overview of Total Nuclear Fuel Cycle*

The environmental effects of the total nuclear fuel cycle have been estimated for mid-1972 and for the projected installed nuclear power generation capacity for 1979-1980. In mid-1972 approximately 10-12,000 MWe of nuclear electric generation capacity is estimated to be in operation in the United States. The projected installed nuclear electric generation capacity for 1980 is 140-150,000 MWe. Table S-6 summarizes industry demands and the number of plants for each fuel cycle step operating in 1972 and estimated required capacity and number of plants required to service the 1980 nuclear electric power generation industry. The environmental considerations for operations have been summarized in Tables 0-4, 0-5, 0-6, 0-7, 0-8, and 0-9. These data characterize the environmental effects of each individual fuel cycle plant. The environmental effects of the total fuel cycle may be obtained by combining the data in Table S-6 for the required number of plants with the corresponding information from Tables 0-4 through 0-9.

Uranium Mining

The existing uranium mining industry can produce about 30% more ore than is required by the nuclear electric generation capacity on-line today. By the end of the decade, the required mining rate must triple to meet the demand. Since the bulk of the known reserves are in New Mexico, Wyoming, Texas, Colorado and Utah, it is expected that the mines will be concentrated in that area. The only anticipated change in mining techniques is that a greater fraction of the ore mined in 1980 may come from underground mines, since a larger percentage of reserves are found at depths only amenable to underground mining.

Uranium Milling

The uranium milling industry is capable of supplying about twice today's nuclear power generation requirements of yellowcake; by 1980, the yellowcake demands are expected to quadruple. It is expected that the number of mills will more than double but it is likely that the technology employed will be similar to today's. The new mills are expected to be located in the Western States in the vicinity of mining operations.

UF_6 Production

It is anticipated that the 1980 requirements for UF_6 can be met by planned UF_6 conversion operations at the reprocessing plants and increases in the plant capacity of the existing facilities and by construction of several new UF_6 plants. No technological advance is forecast at this time.

Isotopic Enrichment

Planned improvements to the government owned complex of isotope enrichment plants will permit the existing plants to supply the amount of separative work required to service the 1980 installed nuclear electrical generation capacity. Since some of the electrical supply for the isotope separation plants is planned to come from nuclear power by 1980, it is estimated that there will be no increase in the gaseous chemical effluents from the enrichments plants despite a 70% increase in separative work capability.

Fuel Fabrication Plant

The fuel fabrication plant industry is presently serviced by 10 plants, some of which are not expected to be in use in 1980. A total of 8 to 10 production plants,

TABLE S-6

TOTAL NUCLEAR FUEL CYCLE INDUSTRY

Types of Plants	1972 Plant Size Thousands of MT	1972 Annual Requirement Thousands of MT	1972 No. of Average Plants Required to Meet Power Demand	1980 (est.) Annual Requirement Thousands of MT	1980 (est.) No. of Average Plants Required to Meet Power Demand
Uranium Mines — Ore	250-750	4,500	10 (220)*	17,000	30-40
Uranium Mills — U_3O_8	0.5-1.1	9	12 (20)*	34	40-45
UF_6 Production — U	5-15	8	1+ (2)*	34**	3 Low Enriched Plants & 3-4 Natural Plants
Isotopic Enrichment SWU	7.5	5	1 (3)*	20	3
Fuel Fabrication — U	0.3-1.2	1.2	3+ (10)*	5.3	8-10
Fuel Reprocessing — U	0.3-1.5	0.2	1 (2)*	3	3-4

*Number in parentheis is number of plants actually available.

**Including recycle of recovered U from reprocessing operations.

Nuclear Power Generation Basis: 10–12,000 MWe 1972
140–150,000 MWe 1980

having a combined throughput of over 5000 MTU of fuel per year, will be required to service the 1980 industry. There are new processes under development in the conversion portion of the fuel fabrication step of the fuel cycle. These new processes are expected to reduce substantially most of the chemical process effluents from fuel fabrication.

Fuel Reprocessing

Three fuel reprocessing plants either exist or are under construction in 1972. It is expected that one additional plant will be built and operating in 1980 to meet the reprocessing load. No major technological advances for these plants are predicted.

Waste Management

The volume of other than high level wastes, i.e., those which may be buried in commercial burial grounds, will increase in about the same ratio as nuclear generation capacity. It is expected that the existing burial grounds will be adequate to handle the 1980 volume of wastes. At the present time and through 1980 high level wastes may be stored at the fuel reprocessing plant site as liquids and solids. This onsite storage does not impose significant environmental effects.

It is expected that by 1980 the Retrievable Surface Storage Facility for storage of solidified high level wastes will be under construction. Hence, at some time after 1980, the high level wastes as solids will be transferred from the reprocessing plant to the Federal facility.

Transportation

At the present time, the transportation needs of the fuel cycle supporting the installed nuclear electric generation capacity can be met by about 1400 truck

shipments per year on public highways. The movement of low specific activity material accounts for most of that total. By 1980, the number of truck shipments could exceed 16,000, however, the use of rail transport may reduce this volume of highway movements. The amount of material shipped will continue to be an inconsequential fraction of the total transportation industry.

F. *IRRADIATED FUEL REPROCESSING*

1. *Summary*

(a) General

Fuel reprocessing recovers the unused fissile material and separates the fission products from the spent fuel discharged by the power reactor. By the middle of the 1970's, three reprocessing plants, with an estimated combined annual capacity of 2700 MTU may be in operation in the United States. The three reprocessing plants are generally similar in regard to process technology, all using mechanical means for cladding destruction and adaptations of the Purex process for a part or all of the separations.[1]

The collective operation of the three plants, normalized to an annual capacity of 900 MTU/yr, is selected as the model reprocessing plant. This capacity is equivalent to the annual fuel requirements of approximately 26 model LWR's.

(b) Environmental considerations

The major environmental considerations associated with irradiated fuel reprocessing, normalized to model LWR annual fuel requirement, are summarized in Table F-1 and as follows:[2]

TABLE F-1

Summary of Environmental Considerations For Irradiated Fuel Reprocessing (Normalized to Model LWR Annual Fuel Requirement)

	Total
Natural Resource Use	
Land (acres)	
Temporarily committed	3.9
Undisturbed area	3.7
Disturbed area	0.2
Permanently committed	0.03
Water (millions of gallons)	
Discharged to air	4.0
Discharged to water	6.0
Total	10.0
Fossil Fuel	
Electrical energy (thousands MW-hr)	0.45
Equivalent coal (thousands MT)	0.16
Effluents	
Chemical (MT)	
Gases	
*SO_x	6.2
**NO_x	7.1
*Hydrocarbons	0.02
*CO	0.04
F–	0.11
Liquids	
Na^+	5.3
Cl^-	0.2
$SO_4^=$	0.4
NO_3^- (as N)	0.2

*Estimated effluent gases from combustion of equivalent coal for power generation.

**23% of total is estimated effluent gas from combustion of equivalent coal for power generation.

TABLE F-1 (Contd.)

Summary of Environmental Considerations For Irradiated Fuel Reprocessing (Normalized to Model LWR Annual Fuel Requirement)

	Total
Effluents	
Radiological (Ci)	
Gases (including entrained matter)	
Tritium (thousands)	16.7
Kr-85 (thousands)	350
I-129	2.4×10^{-3}
I-131	2.4×10^{-2}
Fission products	1.0
Transuranics	4×10^{-3}
Liquids	
Tritium (thousands)	2.5
Ru-106	0.15
Cs-137	0.075
Sr-90	0.004
Thermal (billions of Btu's)	61

(1) Use of Natural Resources

The temporary land use of 3.9 acres comprises roughly 6% of the land use for the total fuel cycle. About 95% of this land use is a fenced in buffer zone and is not disturbed. Less than 0.03 acre per annual fuel requirement is permanently committed. The water use of 10 million gallons comprises about 3% of the water use for the total fuel cycle. Approximately 40% of the water is redistributed through evaporation. The electrical energy requirement of 450 MW-hr. comprises approximately 0.15% of the consumption of electrical energy in the total fuel cycle and is equiva-

lent to the output of the model LWR for less than ½ hr.[3]

The fuel reprocessing component of the nuclear fuel cycle contributes significantly to the conservation of natural resources. The values recovered from the spent fuel can be measured in terms of about 30,000 MT of conserved uranium ore and bred and recovered fissile material worth $1.75 million per model LWR annual fuel requirement.[4]

(2) Effluents

The total radioactivity of airborne radioactive effluents from fuel reprocessing is large (about 65% of the airborne radionuclides) in comparison with the remainder of the fuel cycle. Assuming that all of the Kr-85 and most of the tritium (87%) produced in the nuclear power plant fuel is released to the air during the fuel reprocessing step, the estimated annual whole-body exposure at the site boundary from gaseous effluents is less than 3% of the natural background radiation throughout most regions of the country.[5]

Nearly all of the fission products created in the nuclear reactor are removed from the uranium in the fuel reprocessing step. The activity of the fission products 150 days after discharge from the model reactor is reduced by radioactive decay to roughly 150 megacuries per model LWR annual fuel requirement.[6] The high-level wastes containing most of this radioactivity are stored as liquids in

carefully designed, built and monitored tanks, within vaults, at the fuel reprocessing site for up to 5 years after separation. Eventually they will be converted to inert solids, and will be shipped to a Retrievable Surface Storage Facility within 10 years after separation, and thus isolated from the environment.[7]

Only one of the three plants, Nuclear Fuel Services, comprising the irradiated fuel reprocessing industry discharges radionuclides directly to the watershed. According to measurements made in 1971, the maximum concentrations of tritium and Ru-106 released from processing 69MT of fuel did not exceed 4% of 10 CFR 20 annual average concentration limits in off-site waters.[8] If this plant operated at 300 MT fuel/year, the tritium concentration in off-site waters could reach about 15% of 10 CFR 20 limits. With improved Ru-106 recovery, off-site concentrations of this isotope would be about 0.4% of 10 CFR 20 limits.

Oxides of nitrogen and fluorides are the most significant gaseous chemical effluents from the fuel reprocessing plant. However, the estimated concentrations of NO_x at the site boundaries are more than two orders of magnitude below the 100 $\mu g/m^3$ EPA standard, and the predicted concentrations of fluorides are within the most restrictive State standard of 0.5 $\mu g/m^3$.[9] One of the plants comprising the irradiated fuel reprocessing industry releases chemicals to off-site waters. The incremental increase in concentrations in the receiving

waters is roughly 1 ppm or less, a negligible amount for the chemical species involved.

Some heat, much of it originating from the decay of fission products in stored high level wastes, is discharged to the atmosphere. This thermal effluent amounts to slightly over 1% of that for the total fuel cycle.

(3) Accident Considerations

Fuel reprocessing plants are designed to assure adequate margins of safety to prevent accidents, and to assure that acceptable protection systems will function reliably to mitigate the consequences of accidents if they should occur as a result of multiple failures of systems or procedures that are provided to prevent accidents. A broad spectrum of accidents are analyzed, which range from minor process leaks or spills of radioactive material within the plant and/or its laboratory to credible major accidents such as, but not limited to, criticality incidents, solvent fires, hydrogen explosions, ion exchange resin fire, and typical accidents related to the handling and storage of radioactive materials. Credible accidents are treated as if they might occur during the life of the plant (irrespective of their low probability of occurrence) and the environmental consequence of the release of chemical or radioactive material that might result if the accident should occur is analyzed.[10]

The most significant accidental off-site exposure could result from an accidental criti-

cality incident in these plants. If such an event were to occur, an individual at the site boundary could receive a dose to the thyroid of approximately 40 mrem.[11] In general, other postulated accidents could result in off-site exposures of 10 mrem to the bone of individuals near the site boundary via inhalation and ingestion of fission product and transuranic radionuclides dispersed into the atmosphere by accidental releases. It is significant to note, however, that in more than 25 years of fuel reprocessing experience using similar processes at government owned plants, there has been no accident that has resulted in the release of significant radioactivity to the off-site environs. Based upon the extensive safety measures instituted in new commercial facilities, at least as good a safety record is expected.

(4) Contributions to the General Exposure

The reprocessing plants described in this chapter release all of the noble gases (predominantly Kr-85) and all of the available tritium present in the uranium dioxide fuel 150 days after shut down. A small fraction of the iodine isotopes, and small amounts of mixed fission products and actinides are also released. In the case of NFS, some part of the release is in a low level liquid waste stream.

Kr-85 and H-3 can increase the exposure of the general population. U. S. EPA estimates whole body annual exposure from all reactor produced Kr-85 will be about 0.003 mrem/per-

son in 1980,[12] compared to about 100 mrem/person from natural background. The H-3 produced in all reactors world-wide is estimated to give an annual dose of 0.0006 mrem/person in 1980.[13]

The annual exposure to the population within a 50-mile radius of the model reprocessing plant is estimated to be 167 man-rem, corresponding to 6 man-rem/annual fuel requirement. The average annual dose/person within the 50-mile radius is about 0.055 mrem/person.[14]

2. *Description of the Irradiated Fuel Reprocessing Industry*

Irradiated fuel reprocessing recovers usable fissile material from spent reactor fuel elements. During the operation of a reactor, the buildup of fission products and depletion of fissile material requires that the operator replace between one-fifth and one-third of the fuel elements annually and redistribute the other partially spent fuel in the reactor core. The discharged fuel elements contain about one-third of the uranium-235 that was in the fuel prior to irradiation, and the fissile plutonium that was produced from uranium-238 during irradiation. At present, the recovered uranium-235 is recycled in reactor reload fuel. In the future, the bred plutonium may be used as LWR reload fuel or as fuel in liquid metal fast breeder reactors. At present, the plutonium is isolated and stored.

There are economic and technical considerations which favor recovery and recycle of fissile material from the spent fuel elements. The net value of the residual fissile material, allowing for costs associated with re-

processing, waste disposal, and transportation services, is approximately $50,000 per ton of irradiated fuel. Based on 35 metric tons of uranium reprocessed per year in support of a model 1,000 MWe LWR, the reclaimable fissile material has a net worth of about $1.75 million dollars. These economic savings are reflected in lower electric power costs. The recovered fissile material from an annual fuel requirement also represents the conservation of natural resources equivalent to approximately 30,000 MT of uranium ore.[15]

At present there are three fuel reprocessing plants in operation or being constructed in the United States. One plant has been in operation since 1966, but is presently shut down. Another is nearly completed and will be ready for operation in 1974. The third plant is in an early stage of construction and scheduled for operation in late 1976. The three plants have a combined design capacity to meet the projected needs for fuel reprocessing services until late in the 1970's.[16]

The first commercial fuel reprocessing plant, the Nuclear Fuel Services (NFS) facility, can process irradiated light-water power reactor fuels at the rate of 1 MTU/day. In anticipation of the need for additional commercial services, NFS is giving consideration to increasing the plant's capacity to 900 MTU/year (3 MTU/day).

The second commercial fuel reprocessing plant, the Midwest Fuel Recovery Plant (MFRP), will be ready for operation in 1974. It has a design capacity of approximately 300 MTU/yr.

The Barnwell Nuclear Fuel Plant (BNFP), which will be the third irradiated fuel reprocessing plant, is in its early stages of construction. It is scheduled to

begin operating in late 1976, and will have sufficient capacity to process 1500 MTU/yr.

Each of these plants is located on a relatively large, remote site. Site location, size and demography data for each plant are given in Table F-2. In general, the three fuel reprocessing plants are similar in respect to process technology. All plants utilize mechanical means for breaking up the fuel elements and chemical systems for recovering special nuclear material which are adaptations of the Purex process, for which the technology and risks are well defined. However, specific methods applied for mechanically disassembling the fuel elements, dissolving fuel materials, and applying separation technology to recover fissile materials differ somewhat from plant to plant. A simplified block flow diagram for the plant is given in Figure F-1.

Spent fuel element assemblies are received at the reprocessing plant via truck or rail in heavily shielded shipping casks. The assemblies are spaced arrays of sealed tubular rods containing UO_2 pellets which have been partially transformed into PuO_2, fission product oxides, and gases by irradiation. The tubes encapsulating the fuel are made of zircaloy or stainless steel.

After storage to permit short half-life radionuclides to decay (150 days), the fuel elements are chopped into short pieces, exposing the metal oxides. The metal oxides are leached by hot nitric acid, leaving behind the chopped tubing (hulls). The hulls are soaked in hot nitric acid and water to assure that essentially all of the uranium, transuranics and fission products have been removed. The nitric acid solution, containing uranium, transuranics and fission products, is adjusted chemically and processed through solvent extraction

TABLE F-2

IRRADIATED FUEL REPROCESSING PLANTS
SITE DATA AND DEMOGRAPHY[17]

Plant and Location	Site Size, Acres	Population Density people/ sq. mi.	Population of Nearby Cities		
			City	Population	Distance, Miles
Nuclear Fuel Services, West Valley, N.Y.	3350	90	Buffalo	463,000	28
			West Valley	<1,500	4
Midwest Fuel Recovery Plant — Morris, Ill.	890*	150	Morris, Ill.	8,000	8
			Joliet, Ill.	79,000	15
			Aurora, Ill.	74,000	27
Barnwell Nuclear Fuel Plant — Barnwell, S.C.	1700**	35	Barnwell, S.C.	4,500	7.5
			Aiken, S.C.	16,000	26
			Augusta, Ga.	60,000	33

*Adjacent to the Dresden nuclear reactor site of 2,230 acres.

**Adjacent to AEC Savannah River Plant exclusion area.

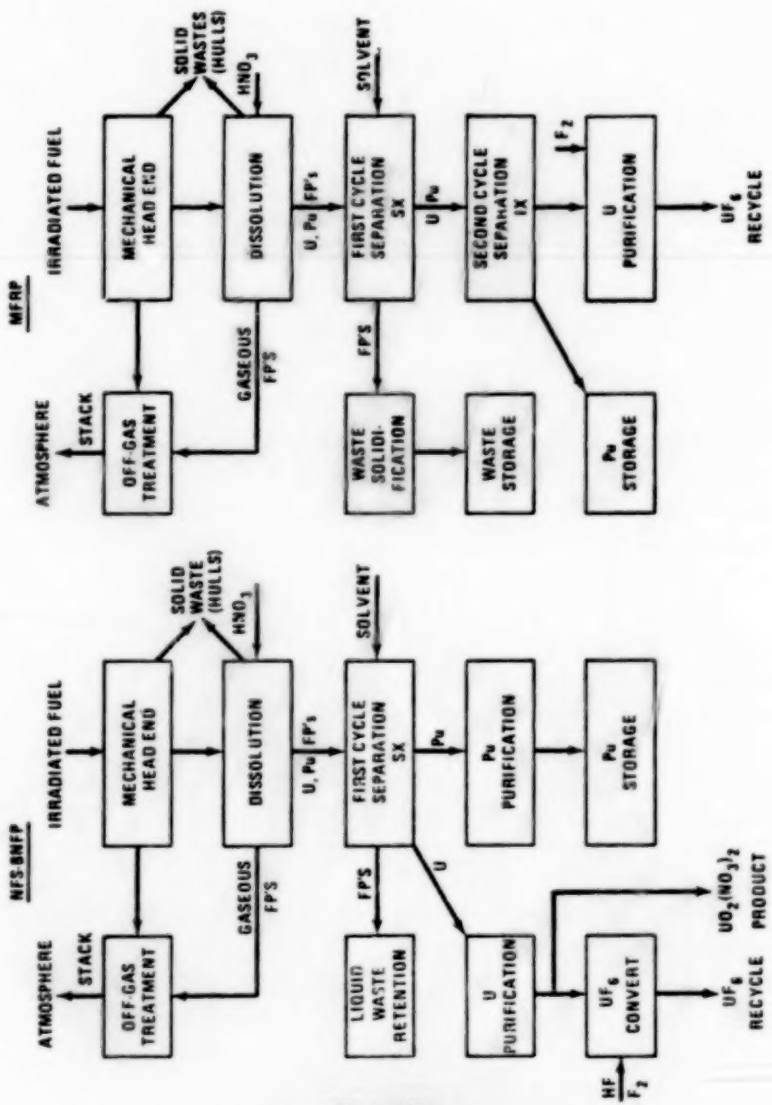

Figure F-1
FUEL REPROCESSING
SIMPLIFIED BLOCK FLOW DIAGRAM

and ion exchange systems. These process steps separate the fission products, uranium, and plutonium, from each other. The purified uranium product is converted to uranium hexafluoride (UF_8) and is shipped to the gaseous diffusion plant for reenrichment. The purified plutonium product will be stored pending conversion to PuO_2 for use in future plutonium recycle or breeder reactor fuel elements (MFRP also recovers and stores neptunium).

In fuel reprocessing technology today, there are two classes of radioisotopes, noble gases and tritium, most of which are released from the fuel to the environs.

Noble gases — Krypton 85 is the dominant noble gas present after 150 days cooling (>99.9% of the noble gas activity comes from Kr-85). It is released quantitatively from the fuel.

The continuous release of all Kr-85 formed in a 1000 MWe reactor can contribute 120 man-rem/year to the entire population of the northern hemisphere; natural background contributes 400 million man-rem/yr. Thus there does not appear to be any significant increase in background from Kr-85 release for many years to come. There is ongoing research sponsored by the U.S. AEC devoted to developing a method for removing Kr-85 from reprocessing off-gases.

Tritium — The behavior of tritium in LWR fuel has been the subject of ongoing study.[18] Tritium can react with Zircaloy to form a solid zirconium compound. It has been reported that from 30-60% of the total tritium formed in the fission process remains with the zirconium hulls. No data are

available on the leaching of tritium from zirconium by nitric acid.

A substantial fraction of the remaining tritium in the fuel remains with the high level liquid waste, but will eventually be released when that waste is solidified. Hence all tritium in the fuel that does not tritide will eventually be released from the reprocessing plant.

In the case of NFS, it has been found that about 40% of the tritium from the plant is released in a low level liquid stream.[19] It has been assumed in this survey that 100% of the tritium formed in the fuel is released in reprocessing.

In the reprocessing operation, certain other radioisotopes are released from the plant stack in small amounts after treatment. Iodine, other fission products, and transuranics may be released. All gaseous effluents are discharged to the atmosphere via off-gas treatment and filtering systems which are designed to remove over 99.9% of the radioactive iodine gas, the radioactive fission products and transuranic particulates.

Of the three commercial reprocessing plants built or being constructed, only NFS has a low level radioactive liquid effluent. In the past, NFS has released tritium, ruthenium, strontium , and cesium isotopes, as well as small amounts of other isotopes; NFS has installed a low level waste treatment system designed to improve the quality of the low level waste discharged (i.e., reduce its radioactivity level). Accounting for creek dilution, values offsite for cesium and strontium have been assumed to be less than 0.1% of MPC.

The major waste systems for each of the three plants are described in Table F-3.

TABLE F-3

IRRADIATED FUEL REPROCESSING PLANTS

MAJOR WASTE SYSTEMS*

Plant	Gaseous Effluents	Liquid Wastes: High-Level	Liquid Wastes: Other Than High-Level	Solid Wastes(3)
NFS	To atmosphere via Iodine Scrubber, HEPA filters, 61 meter stack	Stored onsite as neutralized liquid in tanks in vault(1)	Tritium and Ru-106 controlled release to creek, other isotopes <0.1% of 10 CFR 20 in off-site waters	Stored onsite in drums in impervious clay deposits
MFRP	To atmosphere via Iodine Scrubber, sand filter, 91 meter stack	Converted to solid. Stored onsite in containers under water in storage basin	Stored onsite in tanks in vault as immobile salt cake	Stored onsite in underground lined vault
BNFP	To atmosphere via Iodine Scrubber, HEPA filters, 100 meter stack	Stored onsite as acidic liquid in tanks in vault(2)	Stored onsite in tanks in vault	Stored onsite in underground concrete drums

(1) Plans underway to add tanks for storage of high-level liquids in acidic conditions with ultimate conversion to solids for transfer to a Federal storage facility.

(2) Plans for solidification of high-level liquid wastes for transfer to the Retrievable Surface Storage Facility.

(3) All facilities ship other than high-level solid wastes to commercial burial grounds for long-term storage, with the exception of hulls and fuel hardware which are stored onsite as indicated above.

*The information on this table has been compiled from Safety Analysis Reports from the facilities.

Each plant has provisions for complete containment of high-level liquid wastes in high integrity tanks in vaults or as an immobile solid as shown in Table F-3. The plans vary somewhat, but all result in total retention of the high-level wastes with no release to the environment. Within five years all high-level liquids will be converted to solids and within ten years will be transferred to a Federal storage facility for long-term confinement.[20] Solid waste materials such as hulls and fuel hardware are stored onsite in underground vaults, concrete containers or in impervious soil.[21] Other low-specific activity solid wastes are packaged and shipped to commercial burial grounds for long-term storage. There will be essentially no release of solid radioactive wastes to the offsite environment from any plant.

Plans are under way or under consideration for all three of the plants to process the recovered uranium values to hexafluoride to be recycled through the gaseous diffusion plants. Uranium hexafluoride production results in some nonradioactive chemical effluents of fluoride bearing compounds. The recycled uranium can represent as much as one-third to one-fourth the amount of natural feed to the enrichment operation, so that the potential impact of the fluorination operation at the reprocessing plant corresponds to a fraction of the total environmental impact associated with UF_6 production.

Pending development of a future market for the plutonium product recovered by reprocessing nuclear power reactor spent fuel, the fuel reprocessors tentatively plan to store the plutonium product for the utilities as part of their services. The plutonium product can be stored safely in special containers and facilities

specifically designed for this purpose. The storage of plutonium product at the reprocessing site has been considered in licensing safety evaluations and with respect to the environmental impact of irradiated fuel reprocessing as a whole.

By 1975, the annual quantities of plutonium recovered by reprocessing nuclear power reactor spent fuel will be in the range of 2-3 metric tons; by 1980 about 15 metric tons; and will increase more rapidly thereafter.[23] The feasibility of using about 3 weight percent plutonium in a mixed plutonium-uranium oxide fuel for LWR's has been demonstrated.[24] However, the prospective utilization of such plutonium recycle fuel is somewhat uncertain since the actual timing and the extent to which the recovered plutonium will be recycled is an economic matter to be considered by each utility. Moreover, although several firms have indicated plans to provide production-scale, mixed oxide fuel fabrication plants by 1975 or 1977, the present capability for fabricating such fuel is limited. Accordingly, pending development of the plutonium recycle economy, limited means for storing the recovered plutonium product inventory will be provided at the three reprocessing plants.

The New York State Atomic and Space Development Authority (ASDA) has constructed a plutonium storage facility, for the above purpose, at its Western New York Nuclear Service Center, West Valley, New York.[25] This facility is specifically designed to eliminate the possibility of any significant radiation exposure, criticality incident, or other accidents that might be related to the storage of plutonium in sealed containers. It can store 2 metric tons of plutonium as nitrate in a nitric acid solution. The plutonium nitrate

solution is contained as follows: (a) in a 10-liter polyethylene bottle, (b) that is sealed within a 304 L stainless steel 14-gauge tubular capsule, (c) which is inserted in an eight-inch thick annulus of reinforced concrete with seven-inch thick reinforced concrete bottom and top cover disks, and (d) all of the above are contained within a sealed steel drum. Approximately 1000 such containers can be stored in this facility. Similarly, General Electric Company and Allied-Gulf Nuclear Services plan initially to store Class 1 shipping containers of plutonium nitrate solution within respective protective areas of the MFRP and BNFP."

As the rate of plutonium generation increases due to additional LWR's being placed in operation, other more economical means could be provided for the storage of the larger inventories of recovered plutonium product. At that time, bulk quantities of plutonium nitrate solutions could be stored in vessels within confinement structures specifically designed and constructed for that purpose, or the plutonium nitrate solution could be converted to plutonium dioxide, a solid, which can be sealed in containers and stored in vaults specifically designed and constructed for that purpose. The timing for the start of use of recovered plutonium and the rates for either recycle or storage will be dependent upon an analysis of many changing factors. At this time it is not feasible to make firm projections concerning use of recycle plutonium in LWR's beyond the indication that some recycle may be accomplished by the end of this decade.

On February 1, 1973, the AEC published new proposed requirements for measures of protection of licensed fuel reprocessors against acts of industrial sabotage.[38] All reprocessing plants are required to provide pro-

tection systems to detect unauthorized access to special nuclear materials, i.e., plutonium. Buddy systems, television coverage, perimeter lighting, fencing, and communication with local law enforcement agencies are among the systems that may be required at reprocessing plants.

3. *Environmental Studies of the Effects of Reprocessing Plants*

As stated previously, the United States Government has operated fuel reprocessing plants for over 25 years, with major facilities at Hanford (Richland), Washington and Savannah River (Aiken), South Carolina. Another reprocessing plant is located in Idaho.

NFS, operated from 1966 through 1971, is the only plant in the United States that operated commercially.

Since the normal operations of a reprocessing plant result in the release of some radioisotopes to the environment, a review of the published environmental surveys from the Hanford off-site vicinity, Savannah River Plant off-site vicinity, and the NFS plant vicinity is presented below. It should be pointed out that both Hanford and Savannah River sites contain nuclear facilities, specifically reactors, which may have released radioactivity. In addition, both sites may be larger than commercial reprocessing plants, and the fuel exposure may be significantly different than would be experienced by commercial fuel.

(a) Savannah River Plant — This plant, operated for the AEC by EI du Pont de Nemours and Company occupies 312 square miles in South Carolina. Production areas include fuel preparation area, five reactors, two fuel separations areas, and a heavy

water plant. Only three reactors are now operating.

There has been a continuous monitoring program since 1951, before plant startup, to determine the concentration of radioactive materials in a 1200 square mile area outside the plant.

Semiannual reports of the environmental monitoring are published, and are entitled "Effect of the Savannah River Plant on Environmental Radioactivity."

Reports for the period July 1963—June 1971 were reviewed.[47] Milk has been sampled at four dairies within a 25 mile radius of the SRP over the entire period. Generally, the iodine 131 concentration was below the sensitivity of the analysis over the entire period, and was consistent with U.S. Public Health Service data over most of the United States. (In July—Dec. 1964, the SRP dairy analyses showed <11 pCi/l of I-131, whereas USPHS showed <10 pCi/l for the Atlanta, Georgia, Charlotte, N. C., and Charleston, S. C., milk sheds.)[48] Sr-90 and Cs-137 concentrations over the same period were consistent with USPHS values over most of the United States. Tritium in milk, usually at about 0.1% of applicable concentration guides, was ascribed to SRP operations. At SRP, the reactors are the major sources of tritium.

Radioactivity on vegetation (Bermuda grass) was also analyzed at the plant perimeter and a 25 miles radius. Gamma emitter concentration, ascribed to fallout, was lower in 1971 than in 1963; alpha emitters were of the same order of magnitude (0.2 pCi/g) in 1971 and in 1963.[49]

Analyses of algae and fish in the Savannah River are given. In 1971, du Pont reported that "Radioactive materials in fish flesh continued to be far below levels considered significant from a health standpoint."[30] Data for fish for Jan. — June 1970 are given in Table F-4.[31]

The radioactivity level of the Savannah River upstream and downstream of the plant are reported. The average concentration of any isotope did not exceed 4% of MPC over the entire period, and toward the latter portion, did not exceed 0.5% of MPC. In recent years, Beaufort County, S. C., has received some of its drinking water from the Savannah River, drawn about 90 miles south of the plant. Tritium in the water contributes about 0.17 mrem/yr to an individual drinking 1.2 liters/day. (The reactors are the source of the tritium.) Communities near the SRP obtain water from deep wells or surface streams. There is no evidence that SRP contributed to the radioactivity of public water supplies of towns around the plant, since the alpha and beta emitter concentrations in 1971 were essentially the same as before the plant started up.[32]

(b) Hanford — Operators of the Hanford site have prepared environmental surveys of the vicinity annually for a large number of years. Hanford contains reactors, fuel reprocessing plants, and isotope recovery facilities; as well as fuel fabrication and plutonium processing. Until fairly recently, the reactors operated with once-through cooling water, resulting in the addition of radionuclides from the reactor to the Columbia River. Beginning in 1971 only one production reactor, N,

TABLE F-4

RADIOACTIVITY IN SAVANNAH RIVER FISH, JAN.-JUNE, 1970

pCi/g (wet weight)

Location	Number of Fish Assayed		Type of Sample	^{137}Cs				$^{89,90}Sr$	
				Bream[a]		Catfish[b]		Bream and Catfish	
	Bream	Catfish		Max	Avg	Max	Avg	Max	Avg
Above SRP boundary	18	75	Bone	—	—	—	—	23	12
			Flesh	25	3.2	15	3.6	—	—
Adjacent to SRP	14	27	Bone	—	—	—	—	31	13
			Flesh	18	6.3	21	6.6	—	—
Below SRP at Highway 301	89	22	Bone	—	—	—	—	9	8
			Flesh	20	4.5	11	4.9	—	—

[a]Shellcracker, bluegill, and redbreast (*Lepomis*).

[b]Predominantly yellow cat (*Ictalurus*).

1964

remained in operation. It has a closed primary cooling loop and releases only minor quantities of radioactivity to the river. Thus, the 1971 Hanford Surveillance Program shows the impact of other Hanford operations on the environment. These operations included the Purex chemical reprocessing plant, fuel fabrication for N Reactor, plutonium processing and scrap recovery, and laboratory operations.

Data presented in BNWL-1683, the 1971 Hanford Surveillance Program, shows conclusively that since shutdown of the once-through cooled production reactors, radioactivity released to the environs at Hanford has been reduced to negligible levels.[33] No unusual releases occurred in 1971 causing Concentration Guides, as given in AEC Manual Chapter 0524, Appendix, Table II, to be exceeded. All measurements of radioactivity were less than 15% of the applicable Concentration Guides. Radiation dose estimates for population groups in the plant environs for 1971 were all less than 1% of applicable standards for plant operations. Offsite measurements of other air and water quality parameters were also well within applicable criteria and showed no significant evidence of plant operations.

Highlights of the observations included:

- No measurable effect on Columbia River quality was detectable from wastes released to ground disposal sites within the Hanford plant boundaries.
- Generally, the average airborne radioactive concentrations at the Hanford boundary were the same as the more distant sampling loca-

tions, indicating that Hanford operations were not contributing significantly to offsite airborne radioactivity.

- Average I-131 concentrations in milk locally available were less than 0.5% of the Concentration Guides for water. Increases of I-131 noted in milk for the latter part of 1971 are attributed to atmospheric nuclear weapons testing.
- Cs-137 and Sr-90 were detectable in milk locally available, but concentrations were less than samples obtained from the Puget Sound area — an area of high rainfall; since Richland has a desert climate, the activity is attributed to fall-out.
- Zn-65 activity (250 days half-life) was higher in local farm food-stuffs than commercial foodstuffs and can be attributed to residual activity in irrigation waters resulting from previous reactor operation; however, fallout Sr-90, Cs-137, Ce Pr-144, Zr Nb-95 and Ru-106 activities were higher in commercial foodstuffs than in local farm foodstuffs.
- Plutonium concentrations in soil and vegetation were typical of general regional levels for the arid western states.

The data on I-131 concentrations in milk in 1971 are confirmed in earlier years' reports. The environmental surveys for 1962 and 1963 contain analyses for locally produced milk.[24] The I-131 content was generally below 3 pCi/1, although fallout from weapons testing and some period of above

normals I-131 release from the reprocessing plants caused high readings for short periods. During the 1962-1963 period, the annual average I-131 release ranged from 5 curies/week at the beginning of the period to 3 curies /week at the end of the period.

(c) NFS — The Environmental Protection Agency has recently published an analysis of environmental radiation exposures and population doses from the NFS effluents.[35] The significant radionuclides were Kr-85, tritium, Sr-90, Cs-134, and Cs-137. In 1971, NFS began operating a new low-level waste treatment system to reduce the amount of strontium and cesium in its liquid effluents. EPA concluded that the impact of this facility on humans in 1971 was well below all applicable radiation protection guides. A hypothetical individual maximally exposed locally would receive a whole body dose of 5.8 mrem/year. The plant processed 69 MT of fuel irradiated to 11000 MWD/MT in 1971. Estimating the total exposure in a 50 mile radius gave a total whole body exposure of 12 man-rem. The greatest exposure comes from tritium estimated to be present in Lake Erie, and the ingestion of deer meat. Natural background for the 0-50 mile radius is estimated at 275,000 man rem. The whole body exposure from the plant operating at 300 MT fuel/year at 33,000 MWD/MT is estimated to be 82 man-rem.

4. *Description of the Irradiated Fuel Reprocessing Model*
The mechanisms for discharge of effluents from the three fuel reprocessing plants differ somewhat. For this reason, and because it is likely during the remain-

der of this decade that these facilities will comprise the entire fuel reprocessing industry in the U.S., the collective operation of the three plants is chosen as the basis for the fuel reprocessing model.

The model plant is defined to have a capacity of 900 MTU/yr and the environmental releases and other related considerations are taken to be one-third of the aggregate for the entire industry. This capacity is equivalent to the annual fuel requirements of approximately 26 model LWR's. The model plant occupies a 2,000 acre site and operates for at least 20 years.

5. *Environmental Considerations*

a. Use of Natural Resources

(1) Land

Nearly all of the 2,000 acre site is only temporarily committed. Of this, approximately 100 acres are disturbed by plant construction and 1,900 acres remain an undisturbed exclusion area.[36]

At the end of its useful life, if necessary, the facilities can be dismantled and much of the area reclaimed. The area occupied by the plant itself and waste disposal areas probably could not be restored to its original condition. A conservative estimate is that an area of approximately 15 acres would be permanently committed.

(2) Water

Operations at the model plant will require water at the rate of approximately 600 gpm. This is equivalent to 10 million gallons of

water per model LWR annual fuel requirement. Of this, about 6 million gallons is returned to the surface water and about 4 million gallons is released to air via evaporation and drift from the cooling tower."

(3) Other

The power required to operate the model reprocessing plant is approximately 1.3 MWe. The energy required to produce the annual fuel requirement for the model LWR is 450 MW-hr, which corresponds to the consumption of 160 MT of coal at a fossil fuel fired plant producing this energy.[38]

b. Effluents

(1) Chemical

(i) Gaseous

The chemical off-gas effluents from irradiated fuel reprocessing are oxides of nitrogen, fluoride (associated with UF_6 production), and combustion products from the plant's steam generators. The quantity of NO_x released from the model reprocessing plant is approximately 185 MT annually.

Extensive analyses have been made of the expected concentrations of airborne chemical effluents at the site boundary for the individual fuel reprocessing plants. The calculated site boundary NO_x concentrations are in the range of 0.1 – 1.0 $\mu g/m^3$. These concentrations are orders

of magnitude lower than the EPA standard, an arithmetic mean concentration of 100 $\mu g/m^3$.[39]

Fluoride in reprocessing plant off-gases originates almost entirely from uranium hexafluoride production. The quantity of fluoride released from the model plant is estimated to be approximately 0.1 MT annually. The calculated fluoride concentrations at the site boundaries are below the most stringent state standard for fluoride release, an arithmetic mean concentration of 0.5 $\mu g/m^3$ (State of Washington).[40]

(ii) Liquid

Only one of the three plants releases significant quantities of chemicals in liquid effluents. Table F-5 gives the most significant of these effluents. The estimated release rates are normalized to the capacity of the model reprocessing plant. This table also gives the maximum incremental increase in concentrations in off-site receiving waters. The incremental concentration increases are negligible.[41]

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TABLE F-5

IRRADIATED FUEL REPROCESSING PLANTS
CHEMICALS IN LIQUID EFFLUENTS

Species	Annual Release* MT/yr	Incremental Increase in Concentration in Receiving Water △ppm
Sodium	137	1.3
Chloride	6.3	0.06
Sulfate	11.3	0.1
Nitrate (as Nitrogen)	4.8	0.04

*Normalized to the annual 900 MTU/yr capacity of the model plant.

(2) Radiological

(i) Gaseous

An irradiated fuel reprocessing plant releases airborne effluents containing krypton-85, tritium and minute quantities of radioactive iodine, other fission products and transuranic particulates which might pass through the off-gas treatment and filter systems. Table F-6 quantifies the estimated activity released annually by the model plant, and it relates this activity to the potential maximum exposure to individuals at boundaries of the plants' exclusion areas. These exposure estimates are a) uncorrected for shielding that would be provided by clothing and buildings, b) uncorrected for occupancy time in the area.[42]

On these bases, the annual exposure could be 2.5 mrem to the whole-body, 4.17 mrem to bone, 2.58 mrem to the thyroid, and 9.2 mrem to the outer layer of skin. Thus, the whole-body exposure is less than 1% of that from natural background radiation." The exposures projected for skin, thyroid and bone represent approximately 0.5%, 1.0%, and 0.05%, respectively, of the guideline limits recommended by the International Commission on Radiological Protection, Report No. 9.

(ii) Liquids

Of the three facilities comprising the irradiated fuel reprocessing industry, only the NFS plant release radionuclides in liquid effluents. This results in an equivalent annual release from the model reprocessing plant of approximately 65,000 curies of tritium, 4 curies of Ru-106, 2 curies of cesium-137, and 100 millicuries of Sr-90. Using a stream flow of 358 cu ft/sec at the NFS site boundary," the calculated annual average concentration of tritium is about 5% of 10 CFR 20 limits for a 1 MT/day throughput; other isotopes released at the above rates would be about 0.5% of 10 CFR 20 limits. Estimated man-rem exposure from tritium in drinking water within a 50 mile radius is 50 man-rem.

TABLE F-6

IRRADIATED FUEL REPROCESSING PLANTS

GASEOUS RADIOACTIVE EFFLUENTS[a]

Exposure Mode / Isotope	Annual Release Ci/yr	Exposure, Mrem/yr[a]				
		Whole Body	Thyroid	Bone	Exposed Skin	Lungs
Submersion						
H-3	430,000	.76	.76	.76	.76	.76
Kr-85	9,000,000	.16	.16	.16	6.75	.32
Inhalation[b]				.61		.19
Dietary[c]						
H-3	430,000	1.44	1.44	1.44	1.44	1.44
Sr-90	.18			.94		
Ru-106	3.0	.02		.12	.18	.03
I-129	.06		1.26			
I-131[d]	.6		1.66			
Cs-134	1.2	.09		.07	.09	.02
Cs-137	0.6	.03		.06	.03	.01
		2.50	5.28	4.17	9.25	2.74

(a) Exposure normalized to 900 MT/yr; dose commitment in 50th year exposure at plant boundary.
(b) Dose from isotopes listed plus 25 Ci fission products (calculated as insoluble CE-144) and 0.25 Ci of transuranium isotopes.
(c) 30% of diet from local sources.
(d) 1 l/day milk intake by child.

(iii) Solid

The volume of solid wastes, other than high level wastes, from a model LWR annual fuel requirement is summarized in Table F-7. The undissolved fuel element hulls, containing trace quantities of uranium plutonium, and fission products, and other fuel element parts will be stored or buried on-site in recoverable form and may eventually be shipped to a Federal repository. Discarded equipment will be decontaminated prior to disposal. Laboratory wastes, small tools, gloves, and clothing may be buried on-site or at a commercial burial ground.

TABLE F-7

IRRADIATED FUEL REPROCESSING PLANT SOLID WASTES OTHER THAN HIGH LEVEL LAND BURIAL PER ANNUAL FUEL REQUIREMENT[a]

	Volume, cu. ft.
Undissolved fuel element hulls	350–700
Other fuel element parts and discarded equipment	140–230
Laboratory waste, small tools, gloves and clothing	190–1000

The solid wastes stored at NFS are stored in an essentially impermeable clay strata. At MFRP all solid wastes stored on site are stored in underground vaults equipped to detect, monitor and control water in-

trusion or leakage. At BNFP, solids will be kept in retrievable, sealed concrete drums stored underground.

(3) Thermal

The rate of heat dissipation from the model plant will be about 185 million Btu/hr. This is equivalent to 61 x 10^9 Btu per annual fuel requirement. The heat will be discharged to the atmosphere via the off-gas stack, a cooling tower and a cooling pond. All liquids released offsite will be cooled to ambient temperature prior to release.[46,47]

(4) High Level Wastes

High level liquid wastes containing more than 99.9% of the nonvolatile fission products are concentrated for storage on site in specially built, contained and monitored tanks for a maximum of 5 years. This is followed by conversion to inert solid and, after a maximum on-site storage time of ten years, eventual transfer to a Federally designated disposal site. At 150 days after discharge from the reactor, the activity of the irradiated fuel has decreased by radioactive decay to about 4 megacuries of fission products per MTU or 150 million curies per annual fuel requirement. In addition to the fission product content, there will be approximately 3.5 kilograms of plutonium and 350 kilograms of uranium in the wastes from an annual fuel requirement. The total quantity of high-level waste from an annual fuel requirement can be converted to a solid weighing approximately 1.4 to 2.3 MT.[48]

The MFRP plans on immediate solidification of high level wastes with no intermediate storage as liquid. The off-gases and particulate arising from this operation have been considered in the review of the MFRP.

(5) Man-rem Exposure from the Plants

Although tritium is released from two out of three of the plants comprising the model as a vapor, it can exchange with moisture, or condense and cause exposure when it is ingested as moisture or other tritiated compounds.

Using data in the Detailed Environmental Statements for MFRP and AGNS, and the EPA survey for NFS, the model fuel cycle facility is estimated to expose the population within a 50-mile radius to 167 man-rem most of which is from tritium ingestion.[49] This exposure is equivalent to 6 man-rem/year per annual fuel requirement.

(c) Accident Considerations[50]

At fuel reprocessing plants, operations having a potential for the occurrence of equipment failures or accidents which could disperse significant amounts of radioactive contaminants are performed within shielded process cells. These cells are designed to maintain adequate confinement capability in the event of accidents or natural phenomena much more severe than has been experienced historically for such plants or in the locality of the plant. It is expected that during the life of the plant, some equipment failures will occur. Accordingly, monitors are provided in the

system to detect process or equipment failures and to provide corrective action automatically, or signal a need for corrective action. Moreover, the plant is designed to cope with such failures or accidents, and the cells and equipment are designed so that they can be decontaminated for the repair or replacement of equipment. A ventilation system provides assurance that the contaminated air from within the cells, or from any inadvertent releases within the plant, will be routed through high efficiency filters that remove airborne radioactive particulate before the ventilation air is discharged to the stack. In summary, a fuel reprocessing plant is designed to (a) assure adequate margins of safety to prevent accidents, (b) cope with potential accidents, and (c) mitigate the consequences of accidents if they should occur as a result of multiple failures of systems or procedures that are intended to prevent accidents.

These plants are analyzed with respect to a wide spectrum of credible accidents and the consequence that might result if an accident should occur. While major equipment failures, or spills of radioactive materials within the plant, might disrupt operations and cause the plant to shutdown for cleanup and repair, it is not expected that such occurrences would result in the release of significant amounts of radioactivity so as to contaminate the offsite environs. That is, radioactive contamination would be confined within the process cell, or within the process building, and little if any might escape to contaminate the area in the vicinity of the plant, within the plant's exclusion area. Only a few accidents involving radioactive mate-

rials have occurred in existing plants, and none resulted in significant contamination beyond the immediate vicinity of the plant. The experience gained from these few accidents has resulted in improved safety procedures and features so that the probability of similar occurrences in the future is extremely low. Some examples of the types of accidents that might occur in fuel reprocessing plants, which would have little, if any, discernible impact on the off-site environs, are listed below. This is followed by a brief summary of the more significant potential accidents, irrespective of their low probability of occurrence, and an assessment of the possible consequences if they should occur as a result of multiple failures of systems or procedures that are intended to prevent their occurrence.

The following are examples of types of accidents that are postulated with respect to the analysis of irradiated fuel reprocessing operations. Those listed below are not expected to result in discernible contamination of the environs offsite, nor discernible exposure to the public.

Abnormal Event	Potential Consequence
• Drop fuel cask into cask unloading pool	Possible rupture of fuel pins and release of fission gas to atmosphere; contamination of storage pool water.
• Fuel element hung up in air during transfer to shear	Possible overheating and rupture of fuel pins; release of fission gas to atmosphere.
• Ignition of zirconium fires	Small fire of short duration — little, if any, damage.
• Rapid chemical reaction in dissolver	Vessel pressurized, seals blown, fission gases released to atmosphere; cell contaminated.

Abnormal Event	Potential Consequence
• Leak in recovered acid line	Contamination of cell or pipe trench in area of leak.
• Leak of any vessel or line confining radioactive material	Contamination of cell or pipe trench; transfer material to spare tank space, decontaminate cell and equipment, repair failure or replace equipment.
• Excessive entrainment radioactivity in evaporator overheads	Contamination of recovered acid or effluents, which must be recycled.
• Failure of an iodine scrubber	Reduced iodine removal efficiency of backup systems; shutdown plant until adequate efficiency restored.
• Filter failure	Detectable increase of radioactivity in stack effluent; shutdown plant and replace filter.
• Loss of ventilation zone control differential-pressure	Possible migration of radioactivity from controlled area to limited control area; correct deficiency and decontaminate building area.
• Solvent fire	May plug filter, contaminate cell and ventilation exhaust ducts; could require extensive cleanup of cell and ducts, and replacement of filter, while plant shutdown for repairs.
• Plutonium or waste concentrator explosion	Blowback of air, contamination of cell and possibly adjacent limited control area near cell; could require extensive cleanup of cell and adjacent building area, while plant shutdown for repairs; possible airborne particulate resulting in offsite exposures of less than 1 mrem.
• HF tank leak	Air concentration of toxic HF could be lethal to unprotected persons in vicinity of tank; not discernible offsite.

Table F-8 summarizes the possible consequences of the more significant potential accidents, if such accidents could occur, and is followed by a brief discussion of each accident. Even such major accidents, if they should occur, are not expected to result in radiological exposures that would have any discernible effect on the environment.

TABLE F-8

ESTIMATED RADIATION EXPOSURE AT SITE PERIMETER RESULTING FROM POSTULATED ACCIDENTS[51]

Accident	Organ of Greatest Exposure	Organ Dose (rem)
Criticality incident	Thyroid	0.04
Ion exchange resin fire	Lung	0.001
UF_6 loadout system leak	Bone	0.01
Storage pool cooler leak	Bone	0.01
Fuel assembly rupture	Thyroid	0.002

A criticality incident in a reprocessing plant is an unlikely event because the design of equipment and process limitations prevent such incidents. Safe spacing is ensured in storage basins by physically spacing the fuel elements in safe geometry even when dropped. Process systems and controls are designed to prevent assembly of an unsafe array. Nevertheless, a criticality accident is postulated, in which a burst of 10^{18} fissions is assumed. This yield is approximately an order of magnitude greater than that which has been experienced, on the average, in past accidents. It is further assumed that all noble gases and halogens (or ha-

lides) are discharged from the plant stack without taking credit for filters, and that the airborne fission products arrive at the site boundary 15 minutes after the burst. It is estimated that the whole body exposure from gamma radiation to an individual is approximately 3 mrem, and that the dose to the thyroid from radioiodine is 40 mrem.

Similarly, the design of equipment and process limitations prevent the occurrence and limit the consequences of a postulated ion exchange resin fire. However, in postulating a hypothetical ion exchange resin fire, it is assumed that 128 liters of resin, containing 30 gm of plutonium per liter, are contained in the column section that ruptures and burns. On the basis of known filter efficiencies and the results of burning experiments with metallic plutonium, it is estimated that approximately 10^{-5} of the plutonium, as insoluble plutonium oxide, passes the filter and is expelled through the stack. The resultant dose to the lung of an individual at the site boundary is estimated to be 1 mrem.

In a postulated UF_6 loadout system leak, 350 kg of UF_6 is assumed to escape as a result of a cylinder valve break at the loading temperature. The specific alpha activity of uranium in fuel irradiated to 33,000 MWd/T is approximately 1.4 Ci/kg. If it is assumed that the UF_6 bypasses the filter and is expelled as UO_2F_2 via the stack, the resultant dose to the bone of an individual at the site boundary is estimated to be approximately 12 mrem.

A leak in the storage pool cooler was postulated. The pool water activity is assumed to be approxi-

mately 5 x 10^{-3} μCi/ml. On the basis of Savannah River contaminant composition observations, Ce-144 is chosen to represent the potential hazard of the mixture of contaminants. It is assumed that 1.5 gal/min of cooling water is vaporized during the course of one week. Inspection programs assure detection within one week, and a higher rate of leakage would be detectable earlier. Assuming release outside the containment at ground level in the building wake, the estimated dose to the bone of an individual at the site boundary is approximately 10 mrem.

A fuel assembly rupture is postulated, in which all of the fuel pins in one element rupture under 20 feet of water in the fuel storage pool. One element contains about 0.45 MT of irradiated uranium. The rupture of all of the fuel pins in the element would release approximately one-third of the Kr-85 inventory and 3% of the iodine inventory, i.e., that which had diffused from the fuel into the void space in the fuel element. The gases in the void space would escape and bubble to the surface of the fuel storage pool. However, most of the iodine would be absorbed in the fuel storage pool water. On the basis that one-third of the Kr-85 and 0.1% of the iodine escape to the surface of the fuel storage pool and are exhausted to the atmosphere, the estimated exposure (primarily to the thyroid) of an individual at the site boundary is approximately 2 mrem.

The storage of high-level radioactive liquid wastes in stainless steel tanks within stainless steel lined vaults, with redundant cooling systems, multiple sources of cooling water supply, spare tanks, and

elaborate monitoring and alarm systems is deemed to represent a degree of containment as being essentially accident proof.[52] Moreover, these confinement systems are designed and constructed with a high degree of quality assurance to ensure their capability to withstand accidents, earthquake and tornado effects.[53] For these reasons, the probability of an accidental release of radioactivity is considered to be extremely low and thus there would not be any significant release to the environs.

(d) Contributions to the General Exposure

The reprocessing plants described in this chapter release all of the noble gases (predominantly Kr-85) and all of the available tritium present in the uranium dioxide fuel 150 days after shut down. A small fraction of the iodine isotopes, and small amounts of mixed fission products and actinides are also released. In the case of NFS, some part of the release is in a low level waste stream.

(i) Kr-85

The general exposure from Kr-85 may be assumed to come only from the isotope produced in reactor operation and released at the reprocessing plant. Using estimates for installed nuclear generating capacity, U.S. EPA estimates whole body annual exposure from Kr-85 in 1980 will be 0.003 mrem/person, compared to about 100 mrem/person from natural background.[54]

(ii) Tritium

Tritium is produced naturally by cosmic ray bombardment of oxygen and nitrogen and

arrives directly from outer space. The natural inventory of tritium is estimated at from 25-80 x 10^6 Ci. Weapons have produced another 1-2 x 10^9 Ci. The dose from tritium depends on the H-3 content of food and water. The U.S. EPA has estimated that the total tritium dose from all sources of tritium — weapons, natural, and reactors — will be 0.03 mrem/year per person in 1980. Reactor produced tritium will contribute about 2% of the total.[55]

Tritium emitted from the reprocessing plant can cause exposure in man by direct inhalation, drinking water, and the dietary food chain.

(iii) Iodine

The iodine isotopes are artificial; there is the well established pathway for human exposure of atmospheric discharge → deposition on grass → cattle → milk → man. Other pathways from deposition are possible, as well as the pathway from aqueous release → man. I-131 has an 8.05 day half-life so that accumulations in nature will not occur.

I-129 has a very long half-life, 17 million years; iodine is reported not to concentrate to any appreciable extent in its transfer from soil to plants and to have a possible reaction with soil organic matter to become largely unavailable. Garner therefore concludes that "It appears doubtful, therefor, that a reservoir of I-129 in the soil would pose a long-term problem."[58]

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(iv) Other fission products

Isotopes of ruthenium, strongtium, cesium, cerium, and other fission products may be released from reprocessing plants in small amounts.

Data show that strontium uptake by man is decreasing at about 14%/yr, reflecting the removal effects of leaching, fixation, and removal by plants.[57]

Cesium is known to be firmly bound by clay materials in many soils, and in sandy soils fixation may be complete in about three years after contamination. The general conclusion is that Cs-137 in plant materials has arisen from direct contamination or entrapment of solid particles, although Cs-137 may be taken up from plants grown in organic soils.[58]

Other fission products released in small amounts include Zr/Nb, Ru, and Ce isotopes. Of these, Ru is reported to be slightly excluded (concentration ratio in plant/soil = 0.01-1) and Zr/Nb and Ce are strongly excluded (concentration ratio < 0.01).[59]

Radioisotopes such as strontium, cesium, and ruthenium can, however, reach man by dietary processes to cause exposure. (See Table F-6)

(v) Actinides

Plutonium and other actinides may be released in small amounts from the reprocessing plants. Experiments show that after deposition of particulate and initial stabilization, little or no resuspension of plutonium occurred except

from heavy gusts of winds or mechanical disturbance. Other studies show considerable vertical migration over a 10 year period.[60] Plutonium is strongly excluded by plants (concentration factor < 0.01).[61]

The Final Environmental Statement published by the U.S. AEC for the Midwest Fuel Recovery Plant considers the chronic deposition of I-129 and actinides for the time frame of the plant life in a more quantitative manner than is given above. The conclusion is that the radiological impact of deposited plutonium (used to characterize the actinides) is not expected to exceed that of radioactivity naturally present in the soil. The iodine-129 pool in the soil is expected to require 50 years build up before the dietary supply from this source would be comparable to the pasture-milk route. The MFRP Final Environmental Statement also concludes that the dose from deposited radionuclides in the soil is almost completely due to tritium. The tritium yields a mean average dose of 0.6 mrem over much of the area within a 50-mile radius of the plant.[62]

The annual exposure to the population within a 50-mile radius of the model reprocessing plant is estimated to be 167 man-rem, corresponding to 6 man-rem/annual fuel requirement. The average annual dose/person within the 50-mile radius is about 0.055 mrem/person.[63]

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34. HW-76526, Evaluation of Radiological Conditions in the Vicinity of Hanford, 1962, HW-80991, Evaluation of Radiological Conditions in the Vicinity of Hanford for 1963.

35. "Calculations of Environmental Radiation Exposures and Population Doses Due to Effluents from a Nuclear Fuel Reprocessing Plant," *Radiation Data and Reports*, XIV, No. 2, Feb. 1973, pp. 59-76.

36. See note 1 and the first three documents listed under note 2 above.

37. See note 1 and the first 2 documents listed under note 2.

38. General Electric Company, "Final Safety Analysis — Midwest Fuel Recovery Plant."

Allied-Gulf Nuclear Services, Inc., "Safety Analysis Report — Barnwell Fuel Plant."

Letter, J. F. Wing to W. L. Smalley.

39. See the first three documents listed under item 2 above and letter, J. F. Wing to W. L. Smalley.

40. See the first three documents listed under note 2 above.

41. Nuclear Fuel Services, Inc., "Environmental Report No. 10."
———, "Environmental Report No. 11."

42. *Environmental Quality*

43. *Radiation Data and Reports*, XIV, #2, Feb. 1972, p. 73

44. See Documents listed under note 1, the first three documents listed under note 2, and ORNL-4451.

45. Allied-Gulf Nuclear Services, Inc., "Barnwell Nuclear Fuel Plant Environmental Report."

46. General Electric Co., "Applicant's Environmental Report."

47. Allied-Gulf Nuclear Services, Inc., "Barnwell Nuclear Fuel Plant Environmental Report."

48. ORNL-4451.

49. U.S. AEC, Final Detailed Statement on MFRP. Draft Environmental Statement on the BNFP.

50. All accident analyses are taken from U.S. AEC *Final Detailed Statement of Environmental Considerations of the Midwest Fuel Recovery Plant*, Appendix C.

51. U.S. AEC, Final Detailed Environmental Statement on MFRP, p. 55.

52. South Carolina State Legislature Committee Report, *Report of the Committee to Study the Establishment of Plants or Facilities for the Recovery of Nuclear Fuel and the Storage of Waste Nuclear Materials* (1972).

53. See the second and third documents listed under note 1 above.

54. ORP/CSD 72-1, p. 48.

55. *Ibid.*, p. 43-47.

56. Garner, R. J., *Transfer of Radioactive Materials from the Terrestrial Environment to Animals and Man*, CRC Press, Cleveland, Ohio, 1972, p. 36.

57. Ibid., p. 37.

58. Ibid., p. 38.

59. Ibid., p. 21.

60. Ibid., p. 41.

61. Ibid., p. 21.

62. U.S. AEC, Final Detailed Environmental Statement on MFRP, p. 47, 51.

63. U.S. AEC, Final Detailed Environmental Statement on MFRP, Draft Detailed Environmental Statement on AGNS.

G. *RADIOACTIVE WASTE MANAGEMENT*

1. *Summary*

(a) General

The radioactive wastes resulting from the nuclear fuel cycle can be categorized as high-level and other than high-level. High-level wastes, generated at fuel reprocessing plants, contain fission products separated from fissile material recovered from irradiated fuel. Other than high-level wastes result from operations involving production of UF_6, fuel fabrication, and fuel reprocessing. These include all wastes, regardless of concentration or specific activity, which are not designated as high-level.

Appendix F of AEC regulation 10 CFR 50 requires that the inventory of high-level liquid waste at the fuel reprocessing plant be limited to that produced in the prior 5 years and that it be converted to solid form and be transferred to a Federal repository within 10 years of its separation from the irradiated fuel. The establishment of a means for long-term storage or disposal of high-level wastes is under consideration. Starting about 1980 and until a long-term repository can be established, the Federal government plans to provide the Retrievable Surface Storage Facility (RSSF) as the interim repository for high-level wastes. This interim facility will be designed with capability for storage of wastes for a 100-year period. The Federal government will have responsibility for care and maintenance over the interim facility. Control must be maintained as long as any waste is stored in a facility.

Radioactive wastes other than high-level are buried in near-surface shallow trenches, usually in the containers in which they are shipped. There is no intent to recover the wastes once they are buried. There are 6 commercial land burial sites in the United States authorized to receive and bury other than high-level wastes.

Land used for commercial land burial is owned or controlled by the States. In the event of default or abandonment of the site by the commercial operator, the State is obligated to provide care and maintenance of the site to assure its dedication to radioactive waste burial and to assure it is not used for other purposes.[1]

(b) Environmental Considerations

(1) Resource Use

The waste generated as a result of fuel cycle operations will require the commitment of less than 0.2 acre for the storage of both high-level and other than high-level wastes resulting from the model LWR annual fuel requirement.

(2) Effluents

No effluents to the off-site environment are expected to result from burial of waste classified as "other than high level." Analyses of surrounding streams, test wells and vegetation are used to detect any migration which might lead to offsite contaminations. If any buildup is found, measures will be taken to determine the source and eliminate it.

Under normal conditions, there will be no radioactive or chemical effluents from the Re-

trievable Surface Storage Facility. Releases of radioactivity to air will be minimal, and are estimated to be of the order .005 curies/year.

(3) Accidents

Possible accident effects at commercial land burial facilities would normally be confined to low level contamination of the immediate area of the accident and would not result in release of significant amounts of radioactive material to the environment. However, if there were a release to areas outside the facility, the contaminated areas would be surveyed for radioactivity and decontaminated.

There are two types of accidents involving high level wastes which may be postulated at the RSSF. Catastrophic failure of the proposed water cooling system could result in the eventual meltdown of waste. It is estimated that more than one week would have to elapse without any corrective actions before any meltdown would occur. The safety features, and the number of sequential failures that would have to occur for total loss of cooling and the time period available for corrective action make this accident incredible.

A waste canister handling accident at the RSSF can be postulated which may result in discharge of radioactivity to the air. First year bone dose at the site perimeter is estimated at 0.1 rem.

(4) Contributions to the General Exposure

The low level burial grounds and high level RSSF are not expected to increase significantly the exposure of the general public.

2. *Description of the Radioactive Waste Management Industry*

Radioactive waste generated during fuel cycle operations is divided into two categories, high-level and other than high-level. High-level waste is defined in Appendix F, 10 CFR 50, as the aqueous wastes resulting from the operation of the first cycle solvent extraction system, or equivalent and the concentrated wastes from subsequent extraction cycles, or equivalent, in a facility for reprocessing irradiated reactor fuels. All other solid waste, regardless of its source, falls into the other than high-level category and may be sent to a commercial land burial facility for disposal.

(a) Disposal of Other Than High-Level Wastes

At the present time, there are six commercial land burial facilities which are authorized to receive and bury other than high-level wastes. Five of the sites are on land owned by States and the other site is on land owned by the Federal government and leased to the State. Commercial land burial facilities must be located on land which is owned by either a State or Federal government.[3] The purpose of this requirement is to assure long-term control of the site in the event of default or abandonment of the site by the commercial operator. It is intended that, after radioactive wastes are buried at the site, the land not be used for any other purpose. The States have the obligation for perpetual care and maintenance of land burial sites to assure their dedication to waste burial and to assure that they are not used for other purposes. Authorization to operate a commercial land burial facility is based on an analysis of nature and location of potentially affected facilities and of the site

topographic, geographic, meteorological, and hydrological characteristics, and usage of ground and surface waters in the general area, which demonstrate that buried radioactive waste will not migrate from the site.[4]

Monitoring wells are maintained at most burial sites and are sampled periodically to determine if there has been any migration of radioactivity. In addition, air, water and vegetation samples are taken around the site and analyzed for radioactivity. Should any sample reveal an increase in the concentration of radioactive material in an aquifer above that measured prior to commencement of burial operations and it is determined that the radioactivity originated in the burial ground, its significance must be analyzed, corrective actions developed, as appropriate, and the entire matter reported. Corrective actions are subject to approval by the Atomic Energy Commission or an Agreement State and additional corrective measures may be required as a regulatory agency deems appropriate. An analysis by the U.S. Department of Interior Geological Survey of Sheffield, Illinois burial site predicts migration times through the undisturbed glacial sediment at the site of about 125-150 years, with an increased migration time for ionic material.[5]

To date, there have been no substantiated reports of migration of radioactivity from commercial burial sites. In the unlikely event that there would be such a finding, several courses of action could be taken. These include: (1) a halt to burial operations, (2) removal of the radioactive material from the burial area in which the radioactivity origi-

nated, (3) grouting of the site from which the radioactivity originated, or (4) other such procedures which might be necessary, depending on the extent of migration of radioactivity from the site.

Existing commercial land burial facilities are located in the States of Washington, Nevada, Illinois, Kentucky, South Carolina, and New York. The Illinois facility is licensed by the AEC; the remaining sites are licensed by the states. Currently, about 1,000,000 cubic feet of packaged radioactive waste materials are buried per year.[6] It has been estimated that the annual volume will increase to about 2,000,000 cubic feet by 1975 and 4,000,000 cubic feet by 1980.[7]

An average burial trench at a commercial burial site is about 300 feet long, 30 feet wide, and 20 feet deep and has a volume of 180,000 cubic feet.[8] The volume is not completely utilized since there are voids between packages and between packages and earth fill. Assuming 100,000 cubic feet of waste can be stored in a trench, approximately 10 trenches are needed per year to accommodate the current rate of burial of radioactive wastes. The total land area of the six burial sites is about 600 acres.[9] Assuming 50% usage of available land for trenches, this land area would accommodate over 1400 average burial trenches and would provide for burial of 140,000,000 cubic feet of packaged waste.

The commercial land burial sites are located in rural, sparsely settled areas or in virtually uninhabited areas such as the Armagosa Desert in Nevada.[10] The sites themselves are generally isolated so that public access to them is limited. The

areas in which wastes are buried are enclosed by fences and access to the sites is carefully controlled by the site operator.

The prime operations at a commercial land burial facility are the receipt, temporary storage, and burial in trenches of packaged radioactive wastes. The packages that are shipped to the burial facilities must meet the requirements of the Department of Transportation (DOT) and the Atomic Energy Commission (AEC) for transportation of radioactive material.[11]

The packages are normally buried as received with no reprocessing or repackaging of package contents. However, in some cases, the primary package containing the waste is shipped in a reusable overpack or secondary container which may be required by DOT regulations for shipment of the particular materials involved. In those instances, the primary package is removed from the reusable overpack before burial of the primary package.

The suitability of a site for burial of radioactive wastes depends on the geological and hydrological characteristics of a site and its ability to retain the radioactive material so that there will be no migration of the radioactive material from the burial site. No credit is taken for containment provided by the packages once they are buried. The purpose of the packages is to provide ease of handling and minimization of personnel exposure and to prevent loss of the radioactive material to the surroundings prior to burial.

The volume of packaged radioactive waste consigned to a commercial land burial facility by the

various steps in the fuel cycle is relatively small. There is no waste buried at commercial facilities from operations in the mining, milling, and enrichment steps. During production of UF_6, waste consisting of such things as rags, sweepings, boxes, piping, etc. contaminated with uranium is generated. The average concentration of the waste is low (a few thousandths of a microcurie per gram) and the volume of packaged waste sent to a commercial land burial facility for disposal amounts to a few thousand cubic feet for the model LWR annual fuel requirement.[12] Fuel fabrication operations generate wastes similar to those generated by UF_6 production facilities.

Fuel reprocessing operations generate wastes consisting of general laboratory waste, small tools, gloves, clothing, etc. contaminated with fission products and/or fissile materials.

The volume of waste generated as a result of reprocessing the spent fuel from a model LWR annual fuel requirement ranges from 200 to 1000 cubic feet, depending on the compaction or other volume reduction methods utilized at the fuel reprocessing facility.[13]

(b) High-Level Waste Disposal

Appendix F, 10 CFR 50, requires that the inventory of high-level liquid waste at a fuel reprocessing plant must be limited to that generated in the prior five years. The liquid waste must be converted to dry solids and transferred to a Federal repository no later than ten years following separation of fission products from irradiated fuels.

The solids will contain a variety of fission products and will ultimately be in a non-reactive form.

The spent fuel from a model LWR processed annually in a fuel reprocessing plant produces approximately 10,000 gallons of radioactive liquid waste which, when converted to a solid, weighs approximately 1.4 - 2.3 MT.[14] Assuming that this waste is in the form of calcined solids diluted with twice its volume of inert material, it would occupy a volume of approximately 70 cubic feet.

It was planned to construct a Federal repository in a salt mine for long-term geological storage of solid high-level wastes by the mid 1970's. However, subsequent events have deferred the site selection and construction of such a facility.

The present alternative plan is to design and construct a Retrievable Surface Storage Facility capable of safely storing high-level radioactive waste containers for 100 years or until such time as a permanent Federal repository can be established.[15] The Federal government will have responsibility for the care and maintenance for the RSSF which will be used for storage of high-level waste and the future repository for permanent storage of such waste. The intended life of the RSSF is 100 years; however, the Federal government will have the obligation for care and maintenance as long as any waste is stored in the facility.[16] Although a repository for long-term geologic storage of high-level waste is intended to isolate the waste from man and the biosphere, the Federal government will have the obligation to maintain control over the site in perpetuity.

3. *Description of Model Waste Handling Facilities*

(a) Land Burial Facility[17]

A model land burial facility for other than high-level wastes consists of 100 acres of land located in a rural, sparsely settled area. The site location is near a highway so that there is reasonable access to the site. The site characteristics are such that the ground water is well below the bottom of the deepest trench. The precipitation in the site area is on the order of a few inches per year up to 35-45 inches per year. In a trench in which rainwater could collect arrangements for pumping such water out of the trench are made. The soil provides good ion exchange characteristics to minimize percolation of radioactivity which may be leached from the solid waste to the groundwater. There is no nearby use of groundwater or well water downstream from the site. The site and its vicinity have the characteristically slow water movement through the soil in a direction in which there is little or no land use.

Buildings on the site provide space for offices, a laboratory, temporary storage of packaged radioactive wastes, and other waste handling as may be necessary, such as solidification of low concentration liquids. The storage space is also used for storage of vehicles, earth moving equipment, fork lifts, etc., which are necessary for preparation of trenches and handling of packages containing radioactive wastes.

The portion of the site in actual use is fenced so that access to trenches and buildings is prevented.

The fence also serves to minimize entry by area wildlife.

The operator of a site has a program for environmental monitoring. This program includes sampling of air, water, and vegetation to determine migration, if any, of radioactive material from the actual location of burial. Records are maintained of the monitoring results.

Trenches which are completed are cared for to minimize erosion and are marked to specify the contents. Packages in partially filled trenches are covered over with earth frequently to minimize access to the waste, provide shielding during placement of packages in the trench, and to minimize entry of water into the trench.

The model facility keeps temporary storage of packages to a minimum. Packages are placed in a trench and covered with earth as soon after receipt as possible.

(b) High-Level Waste Storage Facility[18]

In recognition of the need to take timely technical and budgetary steps to assure that facilities are available to accept the commercial high-level waste to be initially delivered in early eighties, the Commission, in the early spring of 1972, announced that it was proceeding on a program to design, construct and operate a surface (or near-surface) facility in which the solidified commercial high-level waste in sealed canisters will be stored. The facility and the canisters will be continuously monitored and maintained, and the canisters may be easily retrieved at any time if future technological

development offers equally safe alternate acceptable options having clear advantage over monitored maintained surface storage.

Since that time, engineering work on: (1) selection of the specific engineering procedures for receiving and handling sealed waste canisters; (2) heat removal, shielding, monitoring and maintenance of canisters and facilities; (3) conceptual design of facilities; (4) selection of site(s) for the facilities; (5) preliminary cost estimates; (6) preliminary analysis of safety under normal and abnormal conditions; and (7) operating and maintenance procedures, has proceeded with the objective that, while actual construction need not be initiated until 1979, all information needed to request Congressional authorization and initial funding for the first module of the repository will be available in time to allow the Commission, should it so desire, to include at least the initial phases of the project in its FY 1976 budget submission.

General Considerations

Any facility used to manage safely the high-level radioactive waste generated by the nuclear power industry must provide that the waste be contained in a way to assure that the radioactive material will not migrate to the environment and that penetrating radiation generated by the waste will not impact on man.

Provision for containment and radiation shielding for the relatively small volumes mentioned earlier would be easily achievable by simple containment were it not for the fact that radioactive decay re-

releases significant quantities of heat for significant time periods (for example, each one foot in diameter by 10 feet long canister may generate as much as 5KW of heat at the time it is received at the RSSF). Should adequate provisions not be made to remove this heat and transfer it to the natural heat sink of the atmosphere, the waste and the canister would melt. Thus, the major factor in the design of the RSSF for high-level waste is the technique used to remove the heat from the waste.

The Commission has carried out extensive evaluations of safety, reliability, operability, maintainability and economics of various methods for removing heat, and has essentially narrowed the area for further study to techniques using either water or air as the heat transfer medium. Water has been selected as the medium used in the reference design, but continuing study and evaluation is being made for the use of air as the coolant.

Reference Design

In the reference design concept, the incoming shipping casks, each containing a number of sealed canisters of waste, are removed from the rail car or truck on which they were transported from the reprocessor, and transferred into the shielded receiving area.

In this area, the shipping cask is opened and the waste canisters are removed for inspection and any necessary decontamination, repair, recanning or precooling.

Following any necessary pretreatment, the individually sealed waste canister is placed in a water

filled transfer cask and transported through a transfer corridor to a water cooled storage basin.

Figure G-1 shows the plan layout of the receiving cell and its relationship to the cask receiving area and transfer corridor. Figure G-2 shows the elevation layout of the receiving cell.

When the transfer cask arrives at the Storage cell, it is removed from its rail transporter and lowered with its contained canister into the water basin. The canister is removed, under water, from the cask and moved into its position in the water cooled storage cell. See Figures G-3 and G-4.

The storage portion of the facility consists of a series of basin modules, each designed to hold five hundred one foot in diameter by ten feet long waste canisters. Each basin has its own cooling system where water is circulated by a pump through a heat exchanger immediately adjacent to the basin. External cooling water is circulated through this heat exchanger where it picks up the heat and is then sent to a cooling tower where the heat is transferred to the outside air.

The total facility will be constructed in segments on a time schedule to meet deliveries from the reprocessors. The estimated number of annual shipments (assuming 12 waste cans per shipment) is as follows:

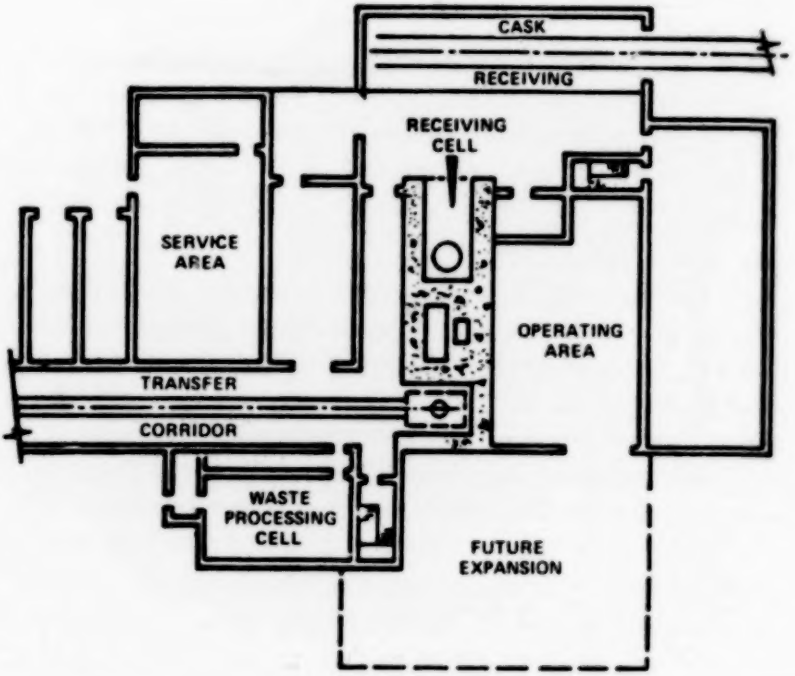

Figure G-1
REFERENCE DESIGN
RETRIEVABLE SURFACE STORAGE FACILITY
CANISTER RECEIVING AREA

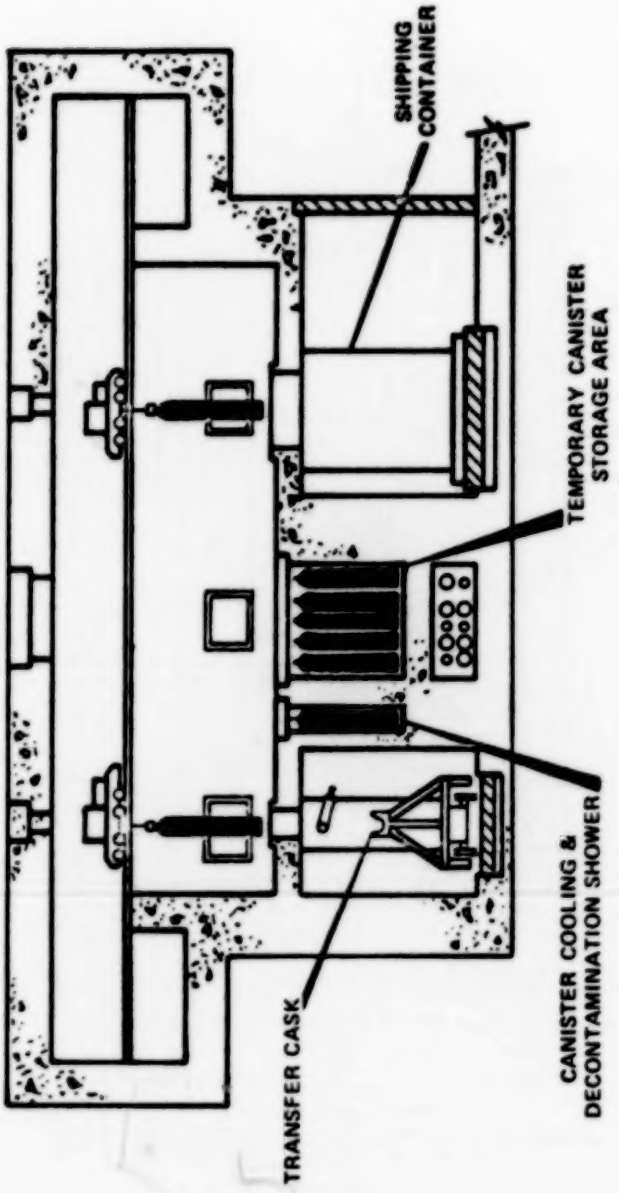

Figure G-2
REFERENCE DESIGN
RETRIEVABLE SURFACE STORAGE FACILITY
CANISTER RECEIVING CELL

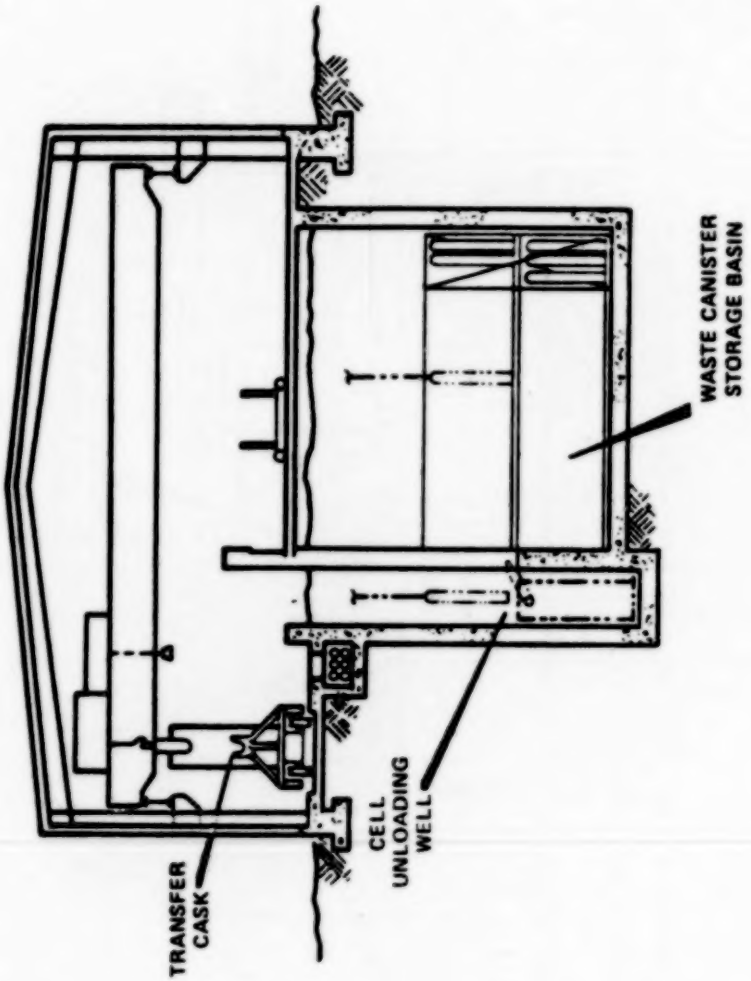

Figure G-3
REFERENCE DESIGN
RETRIEVABLE SURFACE STORAGE FACILITY
CANISTER STORAGE BASIN

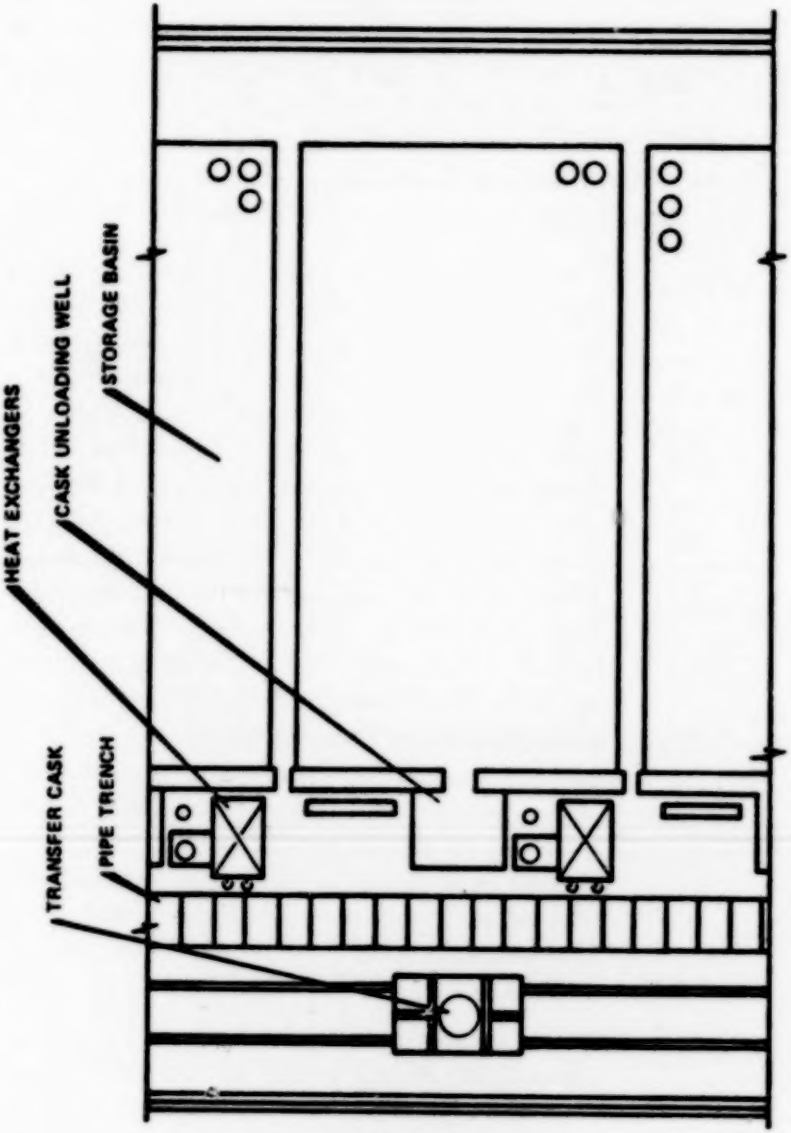

Figure G-4
REFERENCE DESIGN
RETRIEVABLE SURFACE STORAGE FACILITY
CANISTER STORAGE BASIN PLAN

Year	No. of Shipments Received at Repository
1985	20
1990	70

4. *Environmental Considerations*

(a) Use of Natural Resources

(1) Land Use

The volume of other than high-level packaged radioactive waste which is generated during fuel cycle operations is variable and difficult to estimate. However, the total quantity of radioactive material contained in such wastes is small and amounts to only a few curies. It is estimated that the nuclear fuel cycle activities required to produce the annual fuel requirement for a model LWR will generate about 10 curies of radioactive material in other than high-level wastes. This activity will be contained in wastes sent to commercial land burial facilities for disposal. Assuming an average concentration of radioactivity in the waste of 0.025 microcurie per gram and a waste density of 1 g/cc, the total waste volume will be approximately 14,000 cubic feet. Assuming no further compaction of the waste, the final volume of packages containing the waste could approximate 20,000 cubic feet per annual model LWR fuel requirement.

If the waste is packaged in 55-gallon drums, about 3,000 drums would be needed. If the drums are placed in rows 5 deep and 10 wide in an average 30 foot wide burial trench, 60 rows will be required. Since the drums are 2

feet in diameter, a total area of 3600 square feet of land surface will be required. This is less than 0.1 acre.

For the solid high-level waste which would be stored in a Retrievable Surface Storage Facility, it is estimated that the waste from the annual fuel requirement of a model LWR would be about 70 cubic feet and would be stored in 10 containers. It is estimated that about 4000 waste containers would be stored in the initial module of the engineered structure storage facility. About 0.1 acre of land is required for the interim storage of the annual high-level wastes from the model LWR fuel requirement. Based on the above estimates, the land area required for disposal of all radioactive wastes from manufacture and reprocessing of a model LWR annual fuel requirement is less than 0.2 acre.

(2) Water and Other Resources Use

There is very little use of water or other natural resources involved in normal operations involving the burial or storage of solid packaged wastes classified as other than high level generated as a result of fuel cycle operations.

Table G-1 summarizes the water and electrical energy use for the Federal High Level Waste Repository.

(b) Effluents

(1) Chemical and Radiological

The normal operations involved in the burial of "other than high level" radioactive wastes

in solid form are not expected to result in any effluent releases to the offsite environment.

Under normal operating conditions of the high-level waste repository, air releases will be minimal and produce air concentrations both on and off the site that are well below the recommended acceptable concentrations. The sources for occasional releases to the cell air would be material from: (1) receipt of contaminated casks; (2) decontamination of contaminated canisters; (3) repair or over packaging of failed canisters; and (4) miscellaneous clean-up operations around the storage basins. Since all exhaust air will be

Table G-1

SUMMARY OF RESOURCES USE FOR HIGH-LEVEL WASTE MANAGEMENT

	Full Facility	Normalized to an Annual Fuel Requirement of the Model 1000 MWe Reactor
Land Use (acres)		
Temporarily Committed	∿1000	∿0.1
Permanently Committed	∿100	∿0.01
Water Use (millions of gallons) (1)		
Evaporated	∿1000	∿0.13
Cooling Tower Blowdown	∿1000	∿0.13
Electrical Energy (MWH/yr) (2)	∿61 x 10^3	∿7.7
Solid Waste (Cu. Ft.)		
Nonradioactive	∿200/day	∿9
Radioactive	Max. 50/day	Max. 2

NOTES:

(1) Based on evaporation to remove heat plus an equal amount for blowdown.

(2) For pumping water.

filtered through three HEPA filters in series, these events are calculated to result in releases of radionuclides to the atmosphere in the range of 0.005 Ci/yr which is near the lower limit of detection. The maximum concentration of transuranics leaving the stack is estimated to be 1.0×10^{-12} μCi/cc while that of the fission products is 1.7×10^{-10} μCi/cc. For the public at the outer exclusion fence, dispersion, diffusion and dilution would reduce the estimated exposure to a very small fraction of the ICRP recommended maximum exposure.

No contaminated water will leave the facility. However, there may be occasional releases of small amounts of radioactive materials from leaking canisters in underwater storage to cell water. Such an event would be immediately detected by the continuous monitoring of the water in the storage basin. When such canister failure is detected by the basin monitor, procedures are put into effect to isolate the failed canister and remove it for repair or recanning. In the meantime, the basin water is circulated through an ion exchange decontamination system. The contaminated resin is then managed in accordance with its level of radioactivity.

(2) Thermal

Due to the very low concentrations of radioactive materials in the other than high-level wastes that result from nuclear fuel cycle operations, there is essentially no heat release to the environment from these wastes.

Canisters containing solid high-level wastes at the RSSF will generate a small amount of heat. The wastes in each canister (about 7 cubic feet) will generate about 2-5 kw of heat, depending on the elapsed time since the material was first created in the reactor. This heat will be dissipated to the atmosphere. During transfer and storage of canisters in the RSSF, some heat transfer medium will be used to dissipate the heat from the sealed canisters.

(c) Accident Effects

There have been no accidents at burial grounds under Federal or State jurisdictions that resulted in offsite environmental effects. Some minor accidents have occurred involving materials not utilized in any fuel cycle.

Accidental opening of an other than high-level waste package prior to burial and release of the package contents could occur, however, at a commercial land burial facility. Normally, the scattered waste materials would be confined to the fenced facility and the impact on the environment would be negligible. However, even if it is assumed that as much as $\frac{1}{3}$ of the waste contained in a 55-gallon drum is released to the unrestricted area, the effect on the environment would be insignificant. The volume of a 55-gallon drum is approximately 2×10^5 cubic centimeters. Using the assumption made previously of a waste concentration of 0.025 microcurie per gram and density of 1 g/cc, the total amount of radioactivity involved is about 1.7 millicuries. If the waste were uniformly dispersed over an area of one acre, the

concentration of the radioactive material would be about 0.04 microcurie per square foot or 4×10^{-5} microcurie per square centimeter. Dispersion over a greater area would result in a proportionally lower concentration. Much of the dispersed material would be in the vicinity of the site which is normally uninhabited and unused. Recovery of the bulk of the scattered waste could easily be accomplished. Radiation surveys could be made and the area decontaminated.

For the high level waste repository, detailed safety analyses must be based on the specifics of design and of actual site location which are not now available.

Preliminary safety analyses have been made, based on conceptual design and on the assumption that standards for protection against the forces of man and nature used for other nuclear facilities such as reprocessing plants, etc., will apply.

A situation of considerable concern would be loss of ability to remove heat from the stored cans. This would result in melting of the canisters and waste and loss of some fraction of the isolation of the radioactive material from the environment.

The probability of this situation occurring is prevented by a combination of engineered features including, (i) redundancy of power supply and other essential cooling systems; (ii) structural strength to withstand credible forces of nature — earthquake, tornado, etc.; (iii) combination of structural strength, plant security, etc., to withstand credible overt forces of man; (iv) modular basin

cell construction which limits the number of canisters subject to a single castastrophic event.

Thus, before a meltdown could occur, it would be necessary to have a series of failures of systems which will be engineered, constructed, and operated for maximum reliability under rigorous quality assurance programs before a situation could occur where sufficient water could not be added to and maintained in the cell to keep it from leaking or boiling dry. The timing for such a series of failures to result in uncorrectable situations is important. The individual failure of power systems for circulating the coolant would not result in pool water boiling for at least 16 hours. Various corrective actions may be taken any time within a week which would prevent cell water from boiling away. After the complete loss of water, an additional day would be required before the waste would begin to melt. The number of sequential failures required of highly reliable systems, combined with the long time periods available for repair and recovery from each, result in the judgment that this is an incredible incident.

The maximum credible accident that can be conservatively postulated is assumed to take place during one of the various transfers of a single waste canister in air in the receiving cell. It is assumed that the canister is inadvertently dropped to the receiving cell floor. While the canisters are designed to be high integrity vessels and would probably not rupture it is postulated for this analysis that it will rupture, and that its entire contents will be suspended in the air of the receiving cell. The cell air, containing this full load of waste

material, then passes through two sets of HEPA filters. The effluent air from the filters is then assumed to contain 0.02 milligrams of waste per cubic meter of air discharged.[19] It is assumed that the waste is contained in one complete air change or 400 cubic meters. Using the values of 0.02 mg/m^3 and 400 m^3, a release to the environs of 0.008 grams of waste is postulated to have taken place. Dispersion calculations were made using a stack height of 28 meters, under stable conditions and a wind speed of 1 m/sec. The resultant exposure calculations are summarized below:

	At inner exclusion Area fence, 0.2 mile (operator)	At outer exclusion Fence 0.7 mile (public)
Estimated first year bone dose	0.15 rem	0.1 rem

These estimated exposures for operators and the general public are 30% and 20% of the ICRP recommended maximum dose.

(d) Contributions to the General Exposure

Naturally occurring members of the U-235 and U-238 decay chains and small amounts (< 10 Ci/AFR) of fission products and actinide elements may be buried as low level waste as a result of fuel cycle operations. Migration of radioactivity from the burial grounds is not anticipated.

The RSSF will contain fission products and actinides of various ages. Release of these mixed fission products and actinides to the environment is expected to be of the order of 5 millicurie/yr.

The low level burial grounds and high level waste disposal above ground facility are not expected to increase significantly the exposure of the general public — the increase is estimated at about 0.01% of background.

The presence of long-lived radiotoxic actinides in the high-level wastes has been the subject of extensive technical and non-technical articles.

The actinides present in high level wastes are diluted with inert material and with radioactive material of substantially shorter half-lives than, say, Pu 239. Weinberg has estimated that the concentration of Pu 239 in the high level waste is about 39 parts per million. After decay of most of the other radioactivity in the high level wastes, the hazard from the waste is comparable to that of pitchblende ore.[20]

REFERENCES

1. See for example letter from State of Nevada Department of Conservation and Natural Resources to USAEC, "Lease Agreement State of Nevada — Nuclear Engineering Co.," USAEC Docket 27-10 (Feb. 15, 1962).
2. United States Atomic Energy Commission, *Management of Commercial High Level Wastes*, SECY-2371 (March 17, 1972) p. 20.
3. 10 CFR Part 20, Section 20.302.
4. *Ibid.*
5. U.S. Geological Survey, "Report of Geologic and Hydrologic Conditions at a Proposed Site for Burial of Solid Radioactive Waste, Southwest of Sheffield, Bureau County, Illinois," July 1967, p. 19.
6. United States Atomic Energy Commission, *The Nuclear Industry–1971*, WASH-1174-71 (1971) p. 154.

7. *Ibid.*

8. United States Atomic Energy Commission, *Land Burial of Solid Radioactive Wastes: Study of Commercial Operations and Facilities,* WASH-1143 (1968) Table 2, p. 33.

9. *Ibid.*

10. *Ibid.*

11. 10 CFR Part 71, 49 CFR Parts 173 and 177.

12. Allied Chemical Corp., "Application for Source Material License, Amendment," USAEC Docket 40-3392, Feb. 17, 1971.

13. Allied-Gulf Nuclear Services, "Barnwell Nuclear Fuel Plant Applicant's Environmental Report," USAEC Docket No. 50-332 (Nov. 5, 1971) Table 3.6-3, p. 76.

14. *Management of Commercial High-Level Radioactive Wastes,* p. 6.

15. Ibid., pp. 13, 16-17.

16. 10 CFR Part 50, Appendix F.

17. The model presented in this section is based on information in *Land Burial of Solid Radioactive Wastes.* Table 2, p. 33.

18. The model presented in this section is based on information in the statement of Dr. Frank K. Puttman, Director, Waste Management and Transportation, USAEC at the Hearings on the Uranium Fuel Cycle, February 1, 1973, Washington, D.C.

19. ORNL-4451, Siting of Fuel Reprocessing Plants and Waste Management Facilities, ORNL ed., (July 1970).

20. Weinberg, A. M., "Social Institutions and Nuclear Energy," *Science, 177* (July 7, 1972), p. 33.

OVERVIEW OF TOTAL NUCLEAR FUEL CYCLE

The preceding portions of this survey deal with the aspects of the uranium fuel cycle as related to an individual model LWR. To provide additional perspective on the environmental effects of the uranium fuel cycle, an overview of the combined effects from the total uranium fuel cycle industry has been estimated and is included in this section. Since the size and nature of the industry is dependent to a great extent upon the time frame of the evaluation, two time periods have been selected for this overview. The time frames utilized are as follows:

A. The date the survey was prepared (mid 1972); and

B. The end of this decade (1979-1980).

In order to evaluate the environmental effects of the uranium fuel cycle, it is first necessary to establish the size of the industry that it serves. In 1972, about 10-12,000 MWe of nuclear electric generation capability was estimated to be operational in the United States. The existing nuclear fuel cycle industry has capabilities that in general are in excess of the requirements for this size power generation capacity. Table O-1 summarizes the capabilities of the present day nuclear fuel cycle industry and relates these capabilities to the needs of today's power generation capacity.

Although other fuel cycle schemes are competing with the LWR concept, it appears that the prevalent method for generation of electrical power by nuclear energy will continue to be light water cooled and moderated uranium fueled reactors through the end of this decade. Several commercial size high temperature gas-cooled reactors (HTGR) have been committed and are planned to be operational by the end of this decade or the early part of the

next. It is estimated that this component of the nuclear power generation capability will be less than 5% (2-3%) of the nation's capacity by 1980. It is known that some utilities have plans to utilize bred plutonium in the form of mixed oxide LWR reload fuel in the latter part of the 1970's. Production facilities for this type of fuel are being planned and may be in operation during the latter half of the decades small amounts of this fuel could be available in the period 1976-1978. Production quantities of fuel could be expected to be manufactured by the end of the decade and as much as 5% of the total fuel in use by 1980 may be of the mixed oxide (Pu-U) variety. An additional concept for future application is the liquid metal fast breeder reactor (LMFBR). However, it is not expected that any significant application of this concept will be in commercial use by 1980. A commercial scale LMFBR demonstration unit is planned to be in operation early in the next decade. In summary, it appears that the nuclear generation of electric power for the remainder of this decade will be predominantly by the use of LWR's fueled with uranium dioxide and that this concept will constitute 90-95% of the industry throughout this period.

Numerous estimates of the size of the nuclear electric generation industry have been made and have required frequent revisions as a result of changing conditions and schedules. A consensus of these estimates indicate that approximately 140-150,000 MWe may be installed and on line by the year 1980. Based upon this projection, the requirements of the nuclear fuel cycle to service the power generation industry have been estimated and are shown in Table O-2.

TABLE O-1
NUCLEAR FUEL CYCLE INDUSTRY
1972

Type of Plant	Plant Average Annual Capacity Thousands of MT	Total Industry Annual Capacity Thousands of MT	Approx. Annual Demand from Nuclear Power Generation Thousands of MT	No. of Plants Available	Approximate No. of Plants Rqd to Meet Power Needs
Uranium Mines — Ore	250-750	8200	4500	220	10
Uranium Mills — U_3O_8	0.5-1.1	19	9	20	12
UF_6 Production — U	5-15	19	8	2	1+
Isotopic Enrichment — SWU	6	10	5	3	1
Fuel Fabrication — U	0.3-0.5	3	1.2	10	3+
Fuel Reprocessing — U	0.3	0.15*	0.2	2	1

*One plant in operation for about 6 months

TABLE O-2

PROJECTED
NUCLEAR FUEL CYCLE INDUSTRY
1980

Type of Plant	Plant Size Thousands of MT	Annual Requirement Thousands of MT	No. of Average Plants Required to Meet Power Demands
Uranium Mines — Ore	250-750	17,000	30-40
Uranium Mills — U	0.5-1.1	34	40-50
UF_6 Production — U	5-15	34•	3 Low Enriched Plants & 3-4 Natural Plants
Isotopic Enrichment — SWU	7.5	20	3
Fuel Fabrication — U	0.3-1.8	5.3	8-10
Fuel Reprocessing — U	0.3-1.5	3	3-4

•Including recycle of recovered U from reprocessing operations Nuclear Power Generation Basis: 140-150,000 MWe

Uranium Mining

1972

In 1972, domestic uranium mines produced about 6.3 million MT of ore per year having an average assay of about 0.2% U_3O_8. These mines have a total rate capacity of about 8.2 million MT per year. About 70% of the ore is mined in New Mexico and Wyoming with an additional 17% mined in Colorado and Utah. Only about 70% of the ore produced is required to meet the demands of today's nuclear power industry.

Over 98% of the uranium is produced by open pit and underground mining. About one-half of the total ore is produced in 29 open pit mines with individual capacities up to 700,000 MT per year and 193 underground mines with individual capacities up to 230,000 MT per year produce most of the remainder. The environmental considerations for an open pit mine producing 480,000 MT per year are listed in Table O-3.

1980

By the end of the decade, the nuclear electric generation industry will require the mining of about 17 million MT of uranium ore annually. The bulk of the known uranium reserves are in New Mexico, Wyoming, Texas, Colorado, and Utah. It is expected that mining methods will be similar to those used today except that a larger percentage of the ore may be mined using underground mining techniques since a large percentage of the known reserves occur at depths greater than 400 feet. The environmental effect of the uranium mining industry at the end of the decade may be represented by 30-40 mines similar to that shown in Table O-3. However, the average amount of land use per mine is expected to decrease as the percentage of ore mined by underground methods increases.

TABLE O-3

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS FOR OPEN PIT URANIUM MINE — 480,000 MT/YR

Natural Resource Use	
Land (acres)	
Temporarily committed	290
Permanently committed	10
Overburden moved (millions of MT)	14
Water (millions of gallons)	
Discharged to ground	650
Fossil Fuel	
Electrical Energy (thousands of MW-hr)	1.3
Equivalent coal (thousands of MT)	0.5
Effluents	
Chemical (MT)	
Gases	
SO_x	45
NO_x	27
Hydrocarbons	1.6
CO	0.1

Uranium Milling

1972

In 1972, there were approximately 20 mills operational in the United States with a combined capacity of about 17,000 MT of U_3O_8 annually. Of these plants, 70% are within the output range of 500-1100 MT/yr. of U_3O_8. From Table O-1 it is indicated that 1972 nuclear power industry requires only 9,000 MT per year. Thus, it is apparent that approximately one-half of the 20 operational uranium mills would be adequate for that size power generation industry. These mills are located in sparsely populated areas in close proximity to mining operations principally in the States of New Mexico, Wyoming, Colorado, and Utah. The environmental

considerations from a 1000 MT/yr. U_3O_8 uranium milling industry may be characterized by 20 mills each having environmental effects similar to those noted in Table O-4.

1980

The nuclear electric generation industry by the end of this decade will require the operation of about 40-45 uranium mills. It is estimated that these facilities will employ technology very similar to that for 1972's plants with minor technological improvements which will tend to minimize some of the environmental considerations. Since the bulk of the known uranium reserves are centered in the far western States of New Mexico, Wyoming, Colorado, and Utah, it is expected that new milling facilities will be located in those areas near companion mining operations and in sparsely populated relatively arid regions. Thus, the uranium milling industry at the end of the present decade may be represented by 40-45 operating units, each having effects on the environment as listed in Table O-4.

UF_6 Production

1972

The nuclear generation industry requires about 8,000 MT of uranium as uranium hexafluoride (UF_6). The two facilities in operation at the present time have capacity considerably in excess of this level. It is probable that either existing plant could meet this demand without difficulty. Thus, to meet present day requirements, essentially only one UF_6 production plant is required. The environmental considerations for a 5000 MTU/yr. UF_6 production plant are summarized in Table O-5.

TABLE O-4

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS

URANIUM MILL — 1000 MT/Yr. U_3O_8

Natural Resource Use	
Land (acres)	
Temporarily committed	50
Permanently committed (limited use)	250
Water (millions of gallons/yr.)	
Discharged to air	360
Fossil Fuel	
Electric Energy (thousands of MW-hr/yr.)	15
Equivalent Coal (thousands of MT/yr.)	5.4
Natural gas (millions of scf/yr.)	380
Effluents	
Chemical	
Gases (MT/yr.)	
SO_x	485
NO_x (40% from natural gas use for process heat)	485
Hydrocarbons	7
CO	1.7
Liquids (thousands of MT/yr.)	
Tailing Solutions	1300
Solids (thousands of MT/yr.)	
Tailings	500
Radiological (curies/yr.)	
Gases (including airborne particulates)	
Rn-222	410
Ra-226	0.1
Th-230	0.1
U-natural	0.2
Liquids	
U & daughters	11
Solids	
U & daughters	6700
Thermal (millions of Btu/yr.)	390

TABLE 0-5

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS URANIUM HEXAFLUORIDE PRODUCTION PLANT — 5000 MTU/Yr.

Natural Resource Use	
Land (acres)	
Temporarily committed	1400
Permanently committed	10
Water (millions of gallons/yr.)	
Discharged to air	100
Discharged to water bodies	1100
Total	1200
Fossil Fuel	
Electrical Energy (thousands of MW-hr/yr.)	47
Equivalent Coal (thousands of MT/yr.)	17
Natural Gas (millions of scf/yr.)	550
Effluents	
Chemical (MT/yr.)	
Gases	
SO_x	800
NO_x (25% from natural gas for process heat)	280
Hydrocarbons	17.6
CO	5.5
F	3.0
Liquid	
$SO_4^=$	124
NO_{-3}	3
F	243
Cl^-	6
$Na^+ + K^{++}$	93
$Nl^+{}_3$	43
Fe	1.2
Solids	1000

Radiological (curies/yr.)

Gases	
Uranium	0.004
Liquids	
Ra-226	0.0935
Th-230	0.04
Uranium	1.21
Solids (buried)	
Other high levels	24.
Thermal (billions of Btu/yr.)	500

1980

Plans are under way at the present time to initiate the recycle of uranium recovered from the fuel reprocessing step. It appears that each of the fuel reprocessing facilities may have a UF_6 production capability for recycle of recovered uranium values before the end of the decade. The requirements for UF_6 by the end of this decade are estimated to be approximately 34,000 MTU as UF_6. It is estimated that this requirement could be made up from the combined capacities of the planned UF_6 production facilities at the reprocessing plants amounting to 2700 MTU and facilities for production of UF_6 from natural uranium. This expanded demand could be met by the expansion of existing plants to double or triple their present capacity and additional new plants could be added so that a total of 3-4 facilities for the production of natural UF_6 could be operational by the end of the decade. At this time, no significant technological advances can be projected that will affect environmental considerations from these plants. Accordingly, it is projected that UF_6 production plants in 1980 will resemble in most respects the plants of today's era but may be about double their size. Therefore, the industry can be represented by a combination of about 3-4 natural ura-

nium hexafluoride plants, each twice the size of the unit summarized in Table O-5 and three smaller plants handling recovered slightly enriched uranium.

Isotopic Enrichment

1972

The nuclear generation industry in 1972 required about 5,000 MT of SWU to satisfy its present enrichment requirements. The industry is supplied with enrichment services from the complex of the three AEC owned and contractor operated gaseous diffusion plants. Essentially any one of the existing plants operated independently would be adequate to meet this demand. However, since all three installations are operated in a combined fashion, it is difficult to isolate the environmental considerations of an individual plant. Accordingly, the environmental effects of the total three-unit complex as it is operating today are summarized in Table O-6.

1980

It is planned to increase the capability of the existing three-plant complex from about 10,000 MT SWU to 22-27,000 MT SWU. This increased capability will be achieved without the construction of major new gaseous diffusion facilities and will be accomplished primarily by improving and upgrading present units. The modifications will involve installation of improved equipment and increased utilization of electrical power. Thus, no new processing plants are required to meet the projected 1980 industry demands and accordingly the land requirement for this portion of the fuel cycle will remain essentially constant to the end of the decade. It should be noted that the utilities providing power to the gaseous diffusion complex have made commitments for the installation of significant amounts of additional power generation capacity. Included in these commitments are major nuclear generation stations amounting to 8-10,000 MWe of capacity. It is estimated that this switch over from essentially all coal burning power plants to some

TABLE O-6

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS FOR URANIUM ENRICHMENT COMPLEX

Natural Resource Use	1972 10,500 MT SWU	1980 18,000 MT SWU
Land (acres)		
Temporarily committed	1500	1500
Permanently committed	nil	nil
Water (millions of gallons/yr)		
Discharged to air	8100	12,000
Discharged to water bodies*	10^6	1.8×10^6***
Fossil Fuel		
Electrical Energy (thousands of MW-hr/yr)	28,500	41,000
Equivalent Coal (thousands of MT)	10,000	10,000***
Effluents		
Chemical (MT/yr.)		
Gases		
SO_x	400,000	400,000
NO_x	100,000	100,000
Hydrocarbons	1000	1000
CO	2500	2500
Particulates	100,000	100,000
F	45	45
Liquids		
Ca^+	490	880
Cl	740	1130
Na^+	740	1130
$SO_4^=$	490	880
Fe	36	65
NO_3	240	450
Radiological (curies/yr.)		
Gases		
Uranium	0.2	0.3
Liquids		
Uranium	1.8	3.1
Thermal (billions of Btu/yr)	290,000	420,000

*power plant cooling

**67% at power plants

***about ⅓ of electrical power from nuclear stations in 1980.

nuclear powered stations could effectively result in about one-third of the power requirements for the gaseous diffusion complex being provided by nuclear generation facilities. The industry demand in 1980 will require operation of the gaseous diffusion complex at a level of 20,000 MT SWU. Assuming that the plants will be modified to incorporate current improved technology, this level of operation will require approximately 7,400 MW of electrical power. On the basis that two-thirds of the power for this operation could be provided by coal burning power stations, the amount of power supplied by coal fired stations in 1980 will amount to 3,200 MW which is about constant with today's situation. Thus, despite the fact that the separative work capability of the complex will be increased by about 70% and its power rating will be upgraded by about 50%, the major gaseous chemical effluents, which come from the combustion of coal, attributable to the isotopic enrichment function may remain constant with today's levels. The use of natural resources such as water (assuming once through cooling at the power plants) and liquid chemical and all radiological effluents might be expected to increase at a rate essentially equivalent to the increased separative work capability. A summary of the environmental considerations of the enrichment complex in 1980 is listed in Table O-6.

Fuel Fabrication

1972

The fuel requirements for the 1972 nuclear generation industry were approximately 1200 MTU. This capacity was met by 10 existing plants, a number of which have limited capacity and which conduct only a portion of the processes required to produce fuel assemblies for reactors. In fact, only two of the facilities that were in operation in 1972 are large scale production plants which have capacities similar to that considered for the model plant in this statement. The environmental considerations for a 900 MTU fuel fabrication plant are summarized in Table O-7.

TABLE O-7

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS FOR 900 MTU/Yr. FUEL FABRICATION PLANT

Natural Resource Use	
Land (acres)	
Temporarily committed	100
Permanently committed	nil
Water (millions of gallons)	
Discharged to water	135
Fossil Fuel	
Electrical Energy (thousands of MW-hr.)	44
Equivalent Coal (thousands of MT)	16
Natural Gas (millions of scf)	94
Effluents	
Chemical (MT)	
Gases	
SO_x	600
NO_x	160
Hydrocarbons	1.6
CO	4
F	0.1
Liquids	
N as NH_3	220
N as NO_3	140
F	106
Solids	
CaF_2	680
Radiological (curies)	
Gases	
Uranium	0.005
Liquids	
Uranium	0.5
Th-234	0.3
Solids (buried)	
Uranium	6.0
Thermal (billions of Btu)	230

1980

Plans are under development for the expansion of the existing production facilities and for the design and construction of numerous new production type fuel fabrication facilities to replace some of the smaller units now in operation. It is estimated that by the end of the decade, 8-10 production facilities could be in operation to meet the annual requirements of over 5,000 MTU of fuel per year. In the case of fuel fabrication, technological advances have been under development for several years which could have a significant effect on environmental effects. The development of a dry process for conversion of UF_6 to UO_2 has been in progress for some time and it is anticipated that this technique will be used by the end of the decade, substantially reducing both gaseous and liquid chemical effluents that are associated with process operations. This process improvement will essentially eliminate the chemical effluents of ammonia and fluoride. Thus, this industry can be characterized in 1980 by 8-10 plants similar to the one summarized in Table O-7 with the elimination of most of the process chemical effluents.

Fuel Reprocessing

1972

One plant for the reprocessing of commercial nuclear power reactor fuel has been in operation for about six years. This plant is currently shut down for extensive modifications and has operated for only a portion of 1972. A second plant is nearing the operational stage and is planned to be handling irradiated fuel during 1973. An additional plant is under construction for operation by the middle of the decade. As noted in Table O-1 there is little demand for reprocessing services at the present time. Much of that demand has been met by the one plant operating for part

of a year and storage of fuel at that plant planned to be operational in 1973. The environmental effects of the model 900 MTU/yr. reprocessing plant are shown in Table O-8.

1980

It is estimated that three fuel reprocessing plants may be operational before the end of the decade with a combined capability of processing 2,700 MTU annually. A fourth plant is being planned for start-up late in this decade or early in the 1980's. It appears that these plants would be adequate to meet the power industry needs. Thus, the industry in 1980 can be characterized by 3-4 plants similar to the plant outlined in Table O-8.

TABLE O-8

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS OF 900 MTU/YR FUEL REPROCESSING PLANT

Natural Resource Use	
Land (acres)	
Temporarily committed	2000
Permanently committed	100
Water (millions of gallons)	
Discharged to air	100
Discharged to water	150
Fossil Fuel	
Electrical Energy (thousands of MW-hr.)	12
Equivalent Coal (thousands of MT)	4
Effluents	
Chemical (MT)	
Gases	
SO_x	160
NO_x	185
Hydrocarbons	0.5
CO	1
F	14

Liquids	
Na^+	140
Cl^-	0.5
$SO_4^=$	14
NO_3 (as N)	5
Radiological (curies)	
Gases (including entrainment)	
Tritium (thousands)	430
Kr-85 (thousands)	9000
I-129	0.06
I-131	0.6
Fission products	26
Transuranics	0.10
Liquids	
Tritium (thousands)	65
Ru-106	4
Cs	2
Sr-90	0.100
Thermal (billions of Btu)	1600

Waste Management

1972

In 1972, there were six commercial land burial sites in operation in the United States with a total area of approximately 600 acres. Not all of this land is available for actual burial of wastes since some of the land area is needed for support facilities, pre-burial storage, etc. The land available for waste burial is adequate for the amount of radioactive waste generated by fuel cycle industries in 1972, about 1.0-1.5 acres annually. At the present time, there is no requirement for a Federal storage facility for long-term storage of solidified high-level wastes generated as a result of fuel reprocessing operations.

1980

By 1980, it is estimated that the nuclear electric generation capacity will increase to about 12 times present capacity. On this basis, about 12 to 18 acres will be needed for burial of radioactive waste generated by fuel cycle facilities. This would be well within the capacity of the currently existing commercial land burial sites and it does not appear that additional sites would be required. By 1980, it is anticipated that a Retrievable Surface Storage Facility (RSSF) will be under construction for storage of solidified high-level wastes. The high-level wastes, in a combination of liquid and solid forms, could be stored at the fuel reprocessing facilities without significant environmental effects until the RSSF is completed and available for storage of wastes during the next decade.

Transportation

1972

The nuclear power generation industry amounted to 10-12 annual operating units. The transportation needs of the supporting fuel cycle are shown in Table O-9. The movement of low specific activity material constitutes almost all of these shipments. The heat and weight in any shipment and the relatively small number of shipments will essentially have no appreciable effect on the environment. The estimated population exposure for onlookers, people along the route and transportation workers is 4.2 man-rem.

1980

By the end of the decade the size of individual plants may increase and certainly the number of plants will greatly increase. As production levels increase at a particular site, the transportation requirements may favor switching from truck to rail shipment. Typical of this change might be the

TABLE O-9

SUMMARY OF ENVIRONMENTAL CONSIDERATIONS FOR TOTAL NUMBER OF PACKAGES TRANSPORTED ANNUALLY

Step-Material Transported	1972 Total No. of Truck Shipments	1980 Total No. of Truck Shipments
1. Mine to Mill — Ore	40,000	500,000*
2. Mill to UF_6 Production —	140	1,800**
3. UF_6 Production to Enrichment — Natural UF_6	260	3,300**
4. Enrichment to UO_2 Plant — Enriched UF_6	60	750**
5. UO_2 Plant to Fabrication — Enriched UO_2	180	1,400**
6. Low level waste to Commercial Land Burial Sites	700	8,700
7. Solid Wastes to Federal Storage — Fission Products	12(Rail)***	150(Rail)***

*Almost all of these shipments are made on privately owned land.

**Number of shipments may be reduced by shipments from larger processes being switched from truck to larger rail shipments.

***These packages, one (1) per shipment, will be stored at the reprocessing site until after 1980 when the Federal storage and repository facilities are planned for use.

shipment of natural UF_6 in cylinders from the UF_6 production plant to the gaseous diffusion plant.

Despite the fact that the mass handled in transportation should increase by a factor of about 12-15, the quantities involved will continue to be of little consequence with regard to the total transportation industry. A summary of the shipments is shown in Table O-9. The estimated popu-

lation exposure is 53 man-rem. It is assumed that this 53 man-rem exposure will be distributed among at least 600,000 people giving an average exposure of 0.09 mrem/person/year. The dose due to the average natural background radiation is about 100 mrem/person/year.

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FEBRUARY 6, 1972

UNITED STATES OF AMERICA

ATOMIC ENERGY COMMISSION

BEFORE

THE ATOMIC SAFETY AND LICENSING BOARD

In The Matter of:	Docket
CONSUMERS POWER COMPANY MIDLAND PLANT UNITS 1 AND 2	No. 50-329 50-330

SAGINAW VALLEY ET AL. INTERVENORS' STATEMENT OF ENVIRONMENTAL CONTENTIONS

INTRODUCTION

Pursuant to the Order of the Atomic Safety and Licensing Board ("Board"), Intervenors herewith submit their Statement of Environmental Contentions. Intervenors reserve the right to amend this Statement of Contentions, from time to time, as regarding environmental matters relating to the construction of the proposed Midland Units (hereafter referred to as the "proposed Plant" or "Plant").

Notwithstanding the Atomic Energy Commission's or this Board's rulings to the contrary, Intervenors assert that the Atomic Energy Act and the National Environmental Policy Act affirmatively require the Regulatory Staff of the Atomic Energy Commission and this Board, on their own motion, to consider all matters of environmental significance, whether or not such matters are brought to the

attention of the board by the Intervenors. Accordingly, it is our position that the Board must make its own searching inquiry into the validity of the Environmental Statement prepared by the Regulatory Staff, the correctness and scope of Applicants' Environmental Submissions and any other environmental matter which would reasonably come to the attention of an objective and reasonable hearing board. It is for this reason, as well as for the reasons that the Intervenors have been denied access to reasonable discovery in aid of their Statement of Contentions and that all environmental submissions thus far by the Regulatory Staff and the Applicant have failed to discuss all sides of a particular environmental issue (thereby failing to provide to Intervenors sufficient information upon which to base their Contentions) that Intervenors believe that they are entitled to raise as Contentions hereafter any matter which could reasonably be placed before the Board at any time prior to the conclusion of the evidentiary hearing on environmental matters.

Attached hereto as Exhibit A is a preliminary request for certain discovery in connection with this Statement of Contentions. Intervenors, do not, as has been pointed out before, believe it is fair or judicially sound to require discovery to be finalized prior to rulings by the Board as to the scope of environmental inquiry. Moreover, as shall be set forth below, because the submissions of the Regulatory Staff and the Applicant are deficient, not only because they fail fully to discuss issues raised, but also because they fail to discuss at all significant environmental issues, the requirement to finalize discovery at this time is contrary to traditional notions of fair play and justice. Accordingly, Intervenors reserve the right to make their further request for discovery at a point in time when the scope of environmental inquiry has been validly defined by the Board.

I

ENVIRONMENTAL CONTENTIONS RELATING TO THE INADEQUACIES OF THERMAL DISSIPATION DURING NORMAL OPERATION OF THE PLANT

1. Based upon objective engineering data, the cooling pond is of a size insufficient adequately to cool the water dissipated from the Plant during normal operations so as to prevent adverse thermal loading of the Tittabawassee River (hereafter "River"). Adverse thermal loading will impair any proposed plans to revitalize the River. Moreover, adverse thermal loading will lead to further degradation of the River and have at least the following undesirable environmental effects:

   (a) Decreased dissolved oxygen content;

   (b) Fish kills;

   (c) Reduction in benthic organisms;

   (d) Reduction in zooplankton;

   (e) Increase in undesirable phytoplankton;

   (f) Reduction in assimilative capacity for waste water treatment plant effluents;

   (g) Degradation of the quality of waters into which the River flows, including the Saginaw River and Lake Huron;

   (h) Increased undesirable burdens on municipal water treatment plants situated downstream.

2. Because of the meteorological conditions occurring at various times of the year in the geographical vicinities of the Plant, it is improbable, and, therefore, there exists no reasonable assurance, that sufficient make-up water for the cooling pond will be available.

These meteorological conditions include inadequate rainfall, insufficient ground water, low relative humidity, sustained, high wind velocities, and sustained lack of cloud cover leading to increased solar input. As a result of these conditions, and the lack of available make-up water from sources other than the River, cooling facilities will result in higher thermal loading than contemplated in (1) above, aggravating the adverse environmental effects set forth in (1) above.

3. If sufficient make-up water is unavailable from the River and, therefore, as asserted, no discharges are made from the cooling pond to the River, the efficiency of the Plant will be reduced (and on certain conditions available power from the Plant may be drastically reduced or limited) thereby adversely affecting users of electricity in the relevant franchise area who may, from time to time, rely upon the Plant for a dependable source of electricity. These conditions are further aggravated by the fact that as pond water drawdown occurs, the available surface water area for cooling decreases.

4. During periods of insufficient make-up water, undesirable amounts of blue-green algae will proliferate in the cooling pond because of the high thermal content. These undesirable blue-green algae will cause obnoxious odors and adversely affect the health and life of aquatic and terrestrial organisms which will rely upon the cooling pond as a source of food and water. Applicants have suggested that they will control undesirable increases of blue-green algae with the use of massive amounts of chlorine or other undesirable and dangerous chemicals; however, use of chlorine and other undesirable and dangerous chemi-

cals will also have an adverse effect upon the health and life of aquatic and terrestrial organisms which will use the cooling pond as a source of food and water.

5. Operation of the cooling facilities will result in undesirable fogging during certain parts of the year. Fogging will occur during periods when there is a significant difference between the ambient air temperature and the temperature of the cooling pond water. Fogging will be further increased during periods of such difference when there also exists average to high relative humidity. Under conditions conducive to fog, fog will be increased when there exists insufficient make-up water for the cooling pond. Fogging will cause at least the following undesirable environmental effects:

   (a) Decreased visibility on adjacent highways and roads, resulting in hazardous conditions;

   (b) Increase and directly cause icing on adjacent highways and roads during periods when the ambient air temperature is below 0° Centigrade, resulting in hazardous conditions;

   (c) Decreased visibility in the Midland Community, resulting in hazardous conditions;

   (d) Increase and directly cause icing in the Midland Community during periods when the ambient air temperature is below 0° Centigrade, resulting in hazardous conditions;

   (e) Decreased visibility in Dow Chemical and Dow Corning facilities, resulting in hazardous conditions;

   (f) Increase and directly cause icing in Dow Chemical and Dow Corning facilities during periods when

the ambient air temperature is below 0° Centigrade, resulting in hazardous conditions, production outages, and dangerous conditions considering the types of raw materials and products used and produced at such facilities;

(g) Destruction of plant life due to icing;

(h) Destruction of wild birds due to icing;

(i) Impair the efficiency of or break elevated objects, such as poles, wires, towers, and transmission lines.

6. Regardless of the inadequacies of the size of the cooling pond, Applicant will be increasing, by operation of the Plant, the total dissolvable solids in the cooling pond and in the River. Although Applicant asserts that by the time of proposed operation of the Plant the level of total dissolvable solids existing in the River will be decreased, so as to permit an incremental increase as a result of the operation of the Plant, Applicant and the Regulatory Staff have failed to state how this will be accomplished. Increase in total dissolvable solids will cause turbidity on the River and cause various adverse effects, depending upon the nature of the total dissolvable solids, including but not limited to those set forth in (1) above.

7. Under certain conditions, Dow Chemical has contractually agreed to supply make-up water to the Plant. There is no discussion concerning where Dow Chemical will secure the make-up water, whether Dow Chemical will be able to supply the make-up water, whether such supply of make-up water by Dow Chemical will adversely affect the amount of water Dow Chemical itself may need for safe operations of the Dow Chemical and Dow Corning facilities, or whether such sup-

ply of make-up water will adversely affect the supply of water to the greater Tri-City area for drinking purposes, or affect the supply of water as a source of food and water to aquatic and terrestrial organisms within the affected geographic area.

II

DISCHARGE OF CHEMICAL WASTES

8. Applicant plans to discharge chemicals on a regular basis, during operation of the Plant, into the River and Bullock Creek.

9. Dow Chemical already discharges chemicals into the River and Applicant's discharges will have an additive and incremental adverse effect upon the life and quality of the River water, the organisms contained therein, the organisms which rely upon it as a source of food and water, and the ability to revitalize the River. The adverse effects will vary in severity depending upon the character of the chemical.

10. Bullock Creek is an intermittent stream. During periods of the year when Bullock Creek is dry or nearly dry, Applicant's hot chemical discharge will be the only source of water in Bullock Creek. Since the discharges will be at least as high as temperatures from from 80 to 125 degrees Fahrenheit, the severity of adverse effect during such dry periods will be increased.

11. Since Bullock Creek is a tributary to the River, any discharges into Bullock Creek are, in effect, discharges into the River, as well. There is, therefore, an insufficient analysis and discussion of the adverse effects of such discharges.

12. There is a failure to consider and analyze what adverse effects discharges into the Bullock Creek and the River will have upon other bodies of water into which the River runs, such as the Saginaw River and Lake Huron.

13. Since it is possible to remove chemicals by treatment prior to discharge into the Bullock Creek and the River, Applicant's proposed discharges represent an unwarranted cost to the environment. Applicants have not discussed methods of removal, such as the installation of a waste treatment system at the Plant itself or some method of using treatment facilities available at Dow Chemical and Dow Corning.

III

NON-RADIOACTIVE SOLID WASTES

14. There is no discussion of the quantity or character of non-radioactive solid wastes which will be regularly discharged during normal operation of the Plant. Depending upon the method of disposal, there may be adverse environmental effects from such wastes.

15. There is a falure to discuss what relationship, if any, will result between non-radioactive solid wastes created by the Plant and non-radioactive solid wastes normally disposed of by Dow Chemical and Dow Corning. For example, there is no discussion whether such wastes will be used as landfill, what the organic and inorganic composition of the wastes might be, and what effect, if any, such wastes and by-products may have upon the surrounding area, including ground water.

IV

SANITARY WASTES

16. Sanitary waste products created by operation of the Plant are planned to be shipped to Dow Chemical or Dow Corning facilities for treatment or disposal. There is no explanation, discussion, or description of the manner by which such sanitary wastes will be shipped to Dow or the manner by which Dow will dispose of such wastes. Thus, a complete analysis of the effect of sanitary wastes of the Plant must include an analysis of Dow Chemical and Dow Corning sanitary waste systems. Without such a discussion, relative cost-benefit and risk-benefit analyses cannot be made.

V

ENVIRONMENTAL EFFECTS ABSOLUTELY AND INCREMENTALLY, OF THE URANIUM FUEL CYCLE

17. Environmental submissions by Applicant and Regulatory Staff have failed completely to discuss or analyze the absolute and incremental effects upon the environment (including cost-benefit and risk-benefit considerations) of the entire uranium fuel cycle, including the production of uranium by means and methods not presently developed, such as, for example, the Liquid Fast Metal Breeder Reactor ("Breeder"). A great deal is presently unknown by the Atomic Energy Commission, and vendors and utilities in the nuclear industry concerning the effects of an increased surge in nuclear development and use of uranium upon the environment. Below in this section, we set forth considerations known to us at this point, which

must be the subject of an environmental analysis, and without which, a full and complete analysis cannot be made.

18. The Plant will cause, absolutely and incrementally, environmental damage and adverse effects, known to man, from the mining of the uranium, which will be necessary in order to supply fuel for the Plant. It is contended that strip-mining of uranium necessary for fuel for the Plant will without adequate benefits, represent an unwarranted environmental cost to the environment. Additionally, uranium tailings will be produced as a by-product as a result of strip-mining or any other mining of uranium. The disposition of such tailings and its effect upon man and his environment have not been considered. Moreover, during the mining of uranium, many radionuclides are produced such as, for example, radon. These radionuclides are lethal or sub-lethal; and, thus, contribute to the death of man and other organisms and will contribute to long-term contamination of particular geographic areas, making them essentially useless for any alternative purpose. Thus, we contend that this segment of the uranium fuel cycle must not only be discussed in depth, but must also be quantified in any cost-benefit consideration to determine whether the resultant costs and risks (which are incrementally and absolutely created as a result of the proposed Plant) are outweighed by any alleged or asserted benefits.

19. After uranium is mined, the ore must be shipped for milling and processing into yellow cake as the next step in the production of nuclear fuel. Once again, there is absolutely no discussion or consideration of this segment of the fuel cycle, what adverse environmental effects may occur, and whether the costs and

risks are outweighed by alleged or asserted benefits. After uranium is fabricated into yellow cake, it must be further processed into a form of ceramic pellet, which pellets ultimately become a part of the nuclear fuel rod itself (Uranium 235 and Uranium 238). Thereafter, the fuel rods are distributed for use in nuclear power plants and for use in the proposed Plant. There is no discussion of the consequences or adverse effects associated with the reprocessing of yellow cake ultimately into fuel rods, nor is there any discussion or analysis of the costs and risks associated therewith, and whether they are outweighed by any asserted or alleged benefits.

20. Subsequent to the use of fuel rods at the proposed Plant, high and low level radioactive waste products will be generated. High level radioactive wastes from irradiated fuel will be transferred, presumably to a reprocessing center, for separation of plutonium and uranium. Uranium 235, uranium 238, and plutonium presumably will be used once again to create nuclear fuel. However, the major portion of the high level radioactive wastes, which are not uranium or plutonium, then must be disposed of and stored for substantial periods of time. There is no discussion at all of where such high level radioactive wastes will be stored and what incremental burden will be placed upon storage facilities and their surrounding environment as a result of high level radioactive wastes from the proposed Plant. Indeed, the Atomic Energy Commission has, at present, no site selected for the disposition of such high level wastes; and, therefore, as a matter of law, there has not been any cost-benefit or risk-benefit analyses of the disposition of such high-level wastes with respect to asserted or alleged bene-

fits. Intervenors contend that the disposal of such high level radioactive wastes create risks and costs to the environment and result in adverse environmental effects in terms of radiation exposure, which far outweigh any additional benefit, if any, to the electric consumer which may occur as a result of operation of the proposed Plant.

21. During the reprocessing aspect of the uranium fuel cycle, and in addition to radiation hazards connected therewith, there are additional and adverse environmental effects. Current reprocessing plants are fueled by conventional means and in most cases, are fueled by high sulfur coal. The reprocessing plants themselves, in the production of uranium for use at the proposed Plant, adversely affect the environment by emitting particulate matter, sulfur dioxide, oxides of nitrogen, and miscellaneous other noxious substances. Thus, the very production of reprocessed fuel, for so-called clean nuclear power, creates conventional pollutants which are emitted to the atmosphere. There is no discussion, for example, as to whether such conventional pollutants emitted by reprocessing plants in the course of reprocessing fuel would create more costs and risks to the environment than similar conventional pollutants which might be emitted if the proposed Plant were a conventional power plant.

22. In addition to conventional pollutants, reprocessing plants release, in normal operations, radioactivity in gaseous and liquid forms. There is no discussion of the amounts, character, and effects of such radioactive emissions; and since the Atomic Energy Commission does not apply either Part 20 Standards or the as low as practicable formula to reprocessing plants, it is conceivable that the total amount of radio-

active emissions which will reach the environment as a result of the operation of the proposed Plant will exceed safe and tolerable limits. In addition, incremental radioactive releases from reprocessing plants created by virtue of the production of reprocessed fuel for the proposed Plant will be absolutely increased.

23. Environmental submissions by Applicant and the Regulatory Staff admit that low-level solid and liquid radioactive wastes will be generated by operation of the proposed Plant. There is an inadequate discussion of the character or environmental effects of such radioactive wastes; and (in the sense that each radionuclide is not listed either quantitatively or qualitatively), no discussion of the incremental burden on the environment which will be created by such wastes from operation of the proposed Plant. In addition, neither Applicant nor the Atomic Energy Commission has considered fully where such wastes will be transported and stored; accordingly, as a matter of law, there has been no consideration as to whether costs and risks created thereby will be outweighed by alleged or asserted benefits. Indeed, there is no discussion or assurance that adequate facilities for storage and disposal of low-level radioactive wastes incrementally created by the proposed Plant will be available, considering the amount of low-level radioactive wastes generated and available for disposition and storage by nuclear power plants in operation and planned to be in operation during the life of the proposed Plant.

24. Uranium, as a source of fuel, is in low supply. Applicant and the Regulatory Staff have failed to discuss whether sufficient uranium ore will be available to

provide nuclear fuel for the proposed Plant, considering the amount of uranium ore which will be necessary to provide nuclear fuel for other reactors which will be in operation during the life of the proposed Plant. The Atomic Energy Commission has recently announced intentions to construct and develop a Breeder in order to provide further assurance that nuclear fuel will be available for the proposed Plant and other power plants which may be in operation during the life of the proposed Plant. The Breeder presents significant and unresolved safety, scientific, and environmental problems. Neither the Atomic Energy Commission nor the nuclear industry fully understand the risks and costs involved in the construction and operation of Breeders. Since the proposed Plant may rely upon nuclear fuel created by a Breeder, the risks and costs of the development and operation of Breeders must be analyzed against any alleged or asserted benefits, if any, that may be gained by construction and operation of the proposed Plant.

25. If the proposed Plant is constructed, it will have a defined, useful life. At the completion of its defined, useful life, something will have to be done with the Plant and all its radioactive components. Neither the Atomic Energy Commission nor the Applicant have addressed themselves to the economic, environmental, and social costs connected with decommissioning of the proposed Plant. In addition to the failure to have discussed the issue of decommissioning of the proposed Plant, neither Applicant nor the Atomic Energy Commission have any idea as to how they will decommission the proposed Plant, what consequences will result therefrom, what economic costs will be incurred, and what effect decommissioning will have upon the

development of the greater Tri-City area and the health and safety of the surrounding environment, including man and all other organisms. Unless the issue of decommissioning is adequately resolved, an appropriate analysis of risks and benefits associated with construction and operation of the proposed Plant cannot be made.

26. Throughout the Uranium Fuel Cycle, including in a more general sense the proposed development of the Breeder and the decommissioning of the proposed Plant, accidents may occur in the transporting and handling of radioactive material. Accidents may result from negligence or intentional acts, such as sabotage. There exists no meaningful discussion by either Applicant or the Regulatory Staff as to the character of such accidents, ways in which they will be prevented, adverse or beneficial consequences from such accidents, and the economic and other environmental costs associated therewith. To the extent that such accidents increase the total amount of radioactivity emitted to the environment, they represent a consideration for additional costs and risks which must be judged against the alleged or asserted benefits from the proposed Plant.

27. Throughout the Uranium Fuel Cycle, including in a more general sense the proposed development of the Breeder and the decommissioning of the proposed Plant, various amounts of radioactivity in differing character will be released to the environment. Since such radioactivity, by definition, does not dissipate immediately, it tends to build up in the environment and various of its component parts, including man and other organisms and water. Since component parts of the environment tend to concentrate or bio-

logically magnify radiation, the total amount of radiation which could affect man and other organisms is underestimated by Applicant and the Regulatory Staff. Accordingly, both short and long-term risks and costs associated with such magnified radiation have not adequately been assessed in light of presumed or asserted benefits. Biological magnification or concentration occurs in various ways. Thus, for example, radioactive material which is deposited on plant life or soil will ultimately reach water and the organisms contained therein and the organisms depending on that water for their sustenance. Because of biological magnification and concentration, radioactivity originally deposited on the soil and plants will have a far greater adverse effect when man and other organisms are exposed to or ingest such radioactivity at the end of the aforesaid cycle. In addition, there is biological magnification or concentration of radioactivity in food chain cycles, which begin directly by the discharge of radioactivity to water.

28. Applicant and the Regulatory Staff have struck an erroneous balance between the benefits, if any, to be derived from the proposed Plant and the risks and costs involved in the consequences of a postulated loss of coolant accident resulting in an uncontrolled meltdown. Because of the inadequate experimental and other data which underlies the opinions and conclusions of Applicant and the Regulatory Staff regarding the effectiveness of the Emergency Core Cooling System and the so-called Interim Criteria concerning such System and because alternative and safer methods of producing electricity are available, the proposed Plant results in an intentional infliction of risks and costs upon the public and a violation of

the Atomic Energy Act and the National Environmental Policy Act. Intervenors hereby incorporate by reference the substantive contentions in the Petition to Participate filed in Docket RM 50-1 on behalf of the National Coalition of Intervenors. That Petition to Participate sets forth specific contentions respecting the inadequate basis of the Interim Criteria and Applicant's Emergency Core Cooling System, and Intervenors here urge the same contentions in order to challenge the erroneousness of the resolution of the related cost-benefit analysis.

VI

ALLEGED BENEFITS

29. There are no benefits to be derived from operation of the proposed Plant, and, alternatively, all risks and costs greatly outweigh any alleged or asserted benefits.

30. Intervenors contend that there is no valid benefit at all in connection with the proposed Plant. Applicant and Regulatory Staff analyses of the alleged benefits are found respectively at Pages 5.1-1 through 5.1-4 of Volume 1 of Applicant's Supplemental Environmental Report and the bottom half of Page 125 and the first paragraph of Page 126 of the Regulatory Staff's Draft Detailed Statement. Aside from the fact that these discussions are an insult to intelligence, they clearly demonstrate that there are no benefits to be derived from the operation of the proposed Plant.

31. The additional electricity available from the proposed Plant is not a benefit. Additional electric generation through nuclear power merely creates risks and costs to the environment. Moreover, at a time when our

alleged energy demands are increasing, it is not beneficial to continue to add to the production of electricity without increasing our understanding how any demand for electricity is created. And, thus, to the extent that electricity demand is created by virtue of promotional activities or other such efforts of Applicant and the Atomic Energy Commission, any increase of electricity is not a benefit, but an unwarranted cost to the environment. Applicant, other utilities, the Atomic Energy Commission, the Federal Power Commission and the nuclear industry have created an artificial demand for electricity, and no environmental analysis should reward such efforts.

32. Neither Applicant nor the Regulatory Staff has considered the possibility of changing the present social stimuli to society which could result in decreased demand for electricity, thereby not requiring the production of electricity from the proposed Plant. Elsewhere in this statement, we will set forth more specifically our contentions with respect to Applicant's projected load forecasts which we believe are invalid and in some instances untrue.

33. Applicant and Regulatory Staff assert that the proposed Plant would create a benefit resulting from shutting down Dow Chemical's fossil fired facilities. There is no serious anaylsis, however, as to whether Dow Chemical can purchase power from other of Applicant's generating facilities, or whether indeed, in the long run, it would be less costly to the environment to require Dow Chemical to retrofit or update its facilities to provide for fossil fuel generation of electricity without resultant pollutants. In the long run, it would make more sense to require Dow Chemical and others (by denying electricity from the pro-

posed Plant) to investigate ways and means of generating electricity through conventional means or other means not now known to man which could result in less risks and costs than the generation of electricity through nuclear power plants. The assertion that the generation of electricity from the proposed Plant is a benefit because it shuts down fossil fired plants is in reality trading one risk for another. Thus, before such a conclusion is sound, one must evaluate the effects of pollutants from conventional power sources against the effects of normal and abnormal releases of radiation. Since Dow Chemical has been polluting Midland for several decades with its fossil fired facilities, sufficient information should be available to determine what the effects have been and then one could compare them with known effects of radiation upon man and the environment.

34. Applicant and the Regulatory Staff assert that the proposed Plant will provide economic growth for the Midland Community and enable Dow Chemical to expand its facilities by virtue of having available to it low cost energy. There is no discussion, however, as to whether the Midland Community should encourage expanding industry or whether other uses should be found for the land and resources which will be required in such expansion. Moreover, since Dow Chemical presently has available to it in its organization areas, admittedly low cost energy areas, within which it could expand, there must be an analysis of the environmental effects of the Dow Chemical expanding in Midland as opposed to elsewhere in order to justify the suggestion that Dow Chemical's expansion is a benefit. Finally, in any such analysis, if it is determined that the character and type of the Dow

Chemical expansion will result in undesirable products, such as, for example, the creation of chlorinated hydrocarbons or 2-4-5-T, then the subsidization of Dow Chemical by virtue of the construction and operation of the proposed Plant results in additional costs to the environment without any concurrent benefits.

35. Most of the employment asserted to occur as a result of the construction of the proposed Plant is short-termed in duration. No analysis has been made as to whether it would be more sound to arrange permanent employment of the so-called peak labor force of 700 men which allegedly will be used during construction rather than spend millions of dollars in the construction of the Plant for a two or three year employment of 700 men. There will be no significant increase in employment of Dow Chemical as a result of any expansion of its facilities, which may occur as a result of the construction of the proposed Plant; and, in fact, Intervenors contend that the expansion of the Dow facilities will result in a decrease of employment in the Midland Community.

36. Applicant and Regulatory Staff assert that a benefit from the proposed Plant will be additional revenues and taxes. This is a specious argument and clearly is not a benefit entitled to consideration in a NEPA review, since revenues and taxes may flow from undesirable as well as desirable ventures vis-a-vis the environment. Additional taxes and revenues could be generated by proposing higher taxes on existing generating facilities which contribute to pollution and by imposing severe fines on Dow Chemical and Dow Corning for having polluted Midland and other areas of the United States for several decades.

37. Because available statistics demonstrate that nuclear power plants suffer as compared to fossil fired plants, more forced outages for reasons of maintenance, unreliability, and inadequate research, the construction of a nuclear power plant as a base load or peaking load generating facility actually results in inefficient generation of electricity and, accordingly, costs and risks to the environment and not benefits.

38. The proliferation of nuclear power plants and the construction of the proposed Plant will deter research and development into more sophisticated pollution controls for fossil fuel plants, into nuclear safety, in alternative methods of generating electricity, into an analysis of utilities' assertions as to rising demands for electricity and will deter exploration for gas, coal and other fossil fuels. Finally, construction of the proposed plan will further encourage a commitment to nuclear power and the Breeder at a time when there are substantial unresolved areas of scientific and environmental concern.

38A. Applicant has asserted, as stated above, that one of the benefits emanating from the proposed Plant will be the elimination of fossil fired generating capacity both in Applicant's system and in other generating facilities such as Dow Chemical. Assuming the validity of this statement, in order adequately assess the full nature of any alleged benefit, it is important to consider whether the proposed Plant will assist in reducing fossil fired generating facilities of other than Applicant and Dow. Thus, for example, there are generating municipalities and municipal power pools (consumer rather than investor owned) which have demanded purchase from or access to electricity to be generated from the proposed Plant. Assuming the

validity of Applicant's and the Regulatory Staff's contention in this area, it is necessary to analyze whether the Plant is suitably sited and sized in order to spread any alleged benefit throughout the relevant franchise area. The municipalities and consumer owned electrical cooperatives whose needs should be considered in such an analysis include Coldwater, Michigan, Holland, Michigan, Traverse City, Michigan, Grand Haven, Michigan, Zeeland, Michigan, the Northern Michigan Electric Cooperative, and the Wolverine Electric Cooperation. These municipalities and cooperatives have a justifiable interest in purchasing from or access to electricity from the proposed Plant, assuming the validity of Applicant's contention with respect to alleged benefits.

38B. One or more of the above municipalities and cooperatives are so situated so that interconnections could take place between each or all of them and Applicant granting them access to electricity from the proposed Plant, to electricity from Applicant's existing generating facilities and to transmission lines existing or to be built in connection with Applicant's generating of electricity. An adequate environmental analysis of costs and benefits must include the environmental impact which may occur as a result of Applicant's failure to or agreement to provide access to such municipalities and cooperatives to electricity from the proposed Plant and from Applicant's existing generating facilities (including its interconnection partners in the Michigan Power Pool and the ECAR Region) as well as access to transmission lines existing or to be built by Applicant. Thus, the validity of any alleged benefit is a function of that benefit's availability to all coordinating utilities in the relevant area.

Intervenors contend that Applicant's illegal policies regarding the sale of electricity, the sharing of generating facilities, and the nonavailability of its transmission lines has or could result in adverse environmental impact as a result of other coordinating utilities not having an available input into Applicant's huge and monopolistic position in the greater Michigan area.

VII

ALTERNATIVES TO THE PRODUCTION OF ELECTRICITY BY NUCLEAR POWER AND TO THE PRODUCTION OF ELECTRICITY FROM THE PROPOSED PLANT

39. Beginning from the time of initial development of civilian uses of nuclear power to the present, the Atomic Energy Commission, utilities, and the nuclear industry have underestimated, misreported, and misrepresented the safety, environmental impact, and reliability of nuclear power plants for the generation of electricity. Nuclear power plants were constructed and built without respect to the environment until the Atomic Energy Commission amended its illegal policy regarding environmental protection. During this period of time, the Atomic Energy Commission, utilities, and the nuclear industry were actively engaged in the promotion of nuclear power, without respect to criteria and standards necessary for the health and safety of the public and their environmental protection. Significant safety programs such as the Loss of Fluid Test ("LOFT"), although admittedly necessary to analyze the safety of emergency systems, have not been completed. Thus, despite the fact that the

Atomic Energy Commission has admitted that its prior conservative assumptions with respect to safety have not provided reasonable assurance of margins of safety, the Atomic Energy Commission, utilities, and the nuclear industry continue to press for nuclear power plants, content to await necessary safety and environmental research after substantial commitments of resources have been made. The aforesaid and illegal promotional program is intended to subject the general public and persons living within the Tri-City area to the risks of nuclear power plants without sufficent analysis of available alternatives. The program is intended to create a *fait accompli* prior to any meaningful analysis.

40. All of the risks associated with nuclear power, including scientific, safety, and environmental risks with respect to the proposed Plant, have not been explained or released or made available to the public so as to provide a foundation for a cost or risk-benefit analysis. Since the consequences of a loss of coolant or a more severe accident are far greater than the consequences of an accident from a conventional power plant, such risks must be evaluated in light of the relevant benefits, if any, resulting from the construction of a nuclear or fossil fired generating facility.

41. As of January 1, 1972, there were a total of 23 nuclear generating units in operation. These reactors are primarily of an older generation and have a Mw size smaller than the size of the reactors presently planned to be constructed generally as well as the proposed Plant. There has not only been a lack of experience with respect to reactors the size of the proposed Plant, there has also been no experimental data or significant experience with reactors the size

of the proposed Plant or larger. The Atomic Energy Commission's safety program with respect to light water-cooled reactors has been insufficient and devoid of regulatory responsibility. The so-called safety program has been geared to promotion and agrandizement of power by an administrative agency without regard to the public health and safety.

42. The result of substantial commitments of resources prior to analysis of safety and environmental problems has been to encourage the Atomic Energy Commission and others to ignore and avoid a complete analysis of alternative methods for the generating of electricity. This is because the Atomic Energy Commission is a single purpose agency uninterested in sponsoring for any reason the construction of other than nuclear power plants. Accordingly, all analyses by the Regulatory Staff have been biased and non-objective; for example, to date, the Regulatory Staff has not, with respect to any license application, recommended the construction of other than a nuclear power plant. It is inconceivable that an unbiased and objective analysis would not produce at least one instance where other than a nuclear power plant was suggested for construction.

43. As a further evidence of their promotional efforts, the Regulatory Staff and Applicant have failed with respect to the proposed Plant to make a sincere analysis of alternative methods for generating electricity; the Regulatory Staff has not performed any independent inquiry but rather has adopted, uncritically, the position tendered by the Applicant. Thus, inquiries into alternatives have been short-sighted, misrepresented, and, in instances, intentionally colored.

44. A threshold inquiry into the alternatives to the generation of electricity from the proposed Plant is whether additional electrical generation from Applicant is necessary from the proposed Plant in light of all of the relevant circumstances. To the extent that this contention also reflects a need for analysis of the alleged need for power, we incorporate hereby reference that section of these Contentions dealing with the need for power. Additionally, and notwithstanding assertions of need for power, a full and complete analysis of alternatives must include a consideration of all other power available to Applicant from its own system, from utilities from which it is currently purchasing power, and from utilities from which it could purchase power by virtue of contractual or interconnecting commitments.

45. Intervenors contend that there is no need for electricity from the proposed Plant in light of the short and long-term plans of Applicant to build additional facilities. Thus, electricity from the proposed Plant is unnecessary and results in an unwarranted cost to the environment.

46. Applicant, without construction of the proposed Plant, will be able to meet its valid demands for the generation of electricity by virtue of purchasing power from one or more of the following sources:

(a) Power Pools and Regional Associations of which Applicant is a member;

(b) Power Pools and Regional Associations of which Applicant is not a member but which it could join;

(c) Making contractual arrangements for *firm* commitments for power resulting in a guaranteed

source of supply, rather than making no commitments and relying upon future availability;

(d) From other than investor owned utilities, having different peak periods than Applicant, with whom Applicant could interconnect on a national or international basis; and

(e) From investor owned utilities having different peak periods than Applicant with whom Applicant could interconnect on a national or international basis.

In any analysis of the various alternatives available to Applicant (instead of electricity alleged necessary from the proposed Plant), Intervenors contend that all of the long-term construction plans of every available source of power must be considered. In other words, in order to ascertain what sources of power or alternatives are available to Applicant, one must analyze and consider the short and long-term construction program of every available source of power in the United States and Canada. Intervenors contend that an analysis of available sources of power, even assuming a need for power, will demonstrate that the proposed Plant results in an unwarranted cost to the environment.

47. Intervenors contend that Applicant and the Regulatory Staff have been engaged in promotional efforts to create a false demand for electricity; and all of the electricity to be generated from the proposed Plant is, therefore, not necessary for Applicant's franchised area. Accordingly, the construction and operation of the proposed Plant will not provide any benefit to electrical users and the proposed Plant represents an unwarranted cost to the environment. Intervenors

further contend that Applicant, by virtue of advertising campaigns directed toward further use of electricity during peak periods, as well as advertising campaigns deficient in explaining to users in its franchised area methods of decreasing peak period use of electricity, have contributed in whole or in part to the demand for electricity from the proposed Plant; and accordingly, for this additional reason, the proposed Plant represents an unwarranted cost to the environment.

48. Intervenors contend that the sole or primary motivating reason for the proposed Plant is an effort toward public subsidization of a private industry, to wit: Dow Chemical Company. Dow Chemical has available to it methods of purchasing or creating electricity and process steam, which would result in less cost to the environment than the purchase of electricity and process steam from the proposed Plant. Thus, Dow Chemical may retrofit and clean up its own facilities, it may purchase from other than Applicant, it may purchase from other of Applicant's generating facilities, and/or it may expand or move its facilities to other areas of the United States where low cost energy is already available. To the extent that the proposed Plant is to be constructed and operated in substantial part for the benefit of Dow Chemical Company, it represents an unwarranted cost to the environment.

49. Applicant and the Michigan Public Service Commission have illegally created an incentive for continual construction of generating facilities when they are unnecessary. The rate structure imposed upon Applicant by the Michigan Public Service Commission encourages Applicant to create unwarranted costs upon the environment. Because Applicant's ability to

receive a fair return on its invested capital is directly related to outstanding amounts of unamortized construction and other capital costs, Applicant has an incentive to continue to construct power facilities, whether necessary or not, in order to maintain an artificially high rate structure. Specifically, Intervenors contend that Applicant is failing to use existing generating facilities to the extent of their useful lives and it is taking such facilities out of base load or peaking service after such facilities have been amortized and removed from consideration of Applicant's rate structure. Thus, the proposed Plant represents an attempt to construct a facility in order to maintain an artificially high rate structure and, as such, it represents an unwarranted cost to the environment.

50. Applicant and the Regulatory Staff have erroneously concluded that natural resources are unavailable in sufficient quantities to supply fuel for fossil fired power plants. To the contrary, uranium of all fuels is in the shortest supply and considering a rational exploitation of resources, Applicant — if it needs power — should be building other than a nuclear power plant. Intervenors contend that there are sufficient reserves of gas, oil, and coal, individually or collectively, to provide fuel for a fossil fired plant. Moreover, Intervenors contend that it is within the state of the art or would be within the state of the art at the time of completion of construction of a fossil fired power plant, to abate all or substantially all adverse and environmental effects which might occur as a result of a fossil fired plant. Thus, considering availability of resources, pollution abatement, and nuclear safety, the choice of the proposed Plant over

other alternatives represents an unwarranted cost to the environment.

51. Intervenors contend that not only are there sufficient supplies of coal, oil, and gas (and insufficient supplies of uranium), but also that supplies of coal, oil, and gas, are or would be at the time of completion of construction of a fossil fired plant, readily available to Applicant. Assumptions by the Applicant and the Regulatory Staff that coal, gas, and oil, although in existence is not practically available, are a direct result of the massive promotion of nuclear power. Thus, if Applicant finds it is in short supply of gas, oil, and coal, it is not because such resources are unavailable, but rather because Applicant, other utilities, and the Atomic Energy Commission have discouraged exploration and development of coal, gas, and oil reserves. Based upon the availability of coal, oil, and gas and the unavailability of uranium, the proposed Plant represents an unwarranted cost to the environment. To the extent that the Breeder is intended to provide fuel for the proposed Plant during any part of its defined useful life, the environmental, scientific, and safety problems in connection with the Breeder must be analyzed. In this vein, Intervenors contend that the Breeder is subject to such a myriad of unresolved problems that it will never be developed. Moreover, the Breeder will be the subject of intensive litigation and, accordingly, any reliance upon the Breeder for fuel in the near or short-term, is an unwarranted assumption.

52. Even considering the generation of any needed electricity by a fossil fired plant without additional pollution abatement facilities, harmful and adverse effects and dangers from radiation greatly outweigh any

harmful and adverse effects from pollution which may be emitted from a fossil fired plant. This is because radiation effects are long-term in contrast to effects of conventional pollutants, because radiation effects cover a broader geographical area than do effects of pollutants from a given fossil fired plant, because available safety measures are more sophisticated and more reliabe in fossil fired plants, and because a fossil fired plant is more reliable in terms of maintenance and forced outages. Accordingly, the selection of the proposed Plant imposes an unwarranted cost upon the environment.

53. Proliferation of nuclear power plants and the building of the proposed Plant deter persons, firms, corporations, and government from research and development into alternatives to nuclear power. Since, because of a short supply of uranium and the present inability to resolve problems concerning the Breeder, nuclear technology is a "stop gap" and short-term technology, construction and operation of the proposed Plant will continue to deter research and development into alternative methods for the generation of electricity, such as fusion, solar energy, magnetohydrodynamics, geothermal and other methods for the production of electricity. As a result, the construction of the proposed Plant represents a serious and unwarranted long-term cost and risk to the environment and to the development of future and alternative methods for the generation of electricity which may be needed in the future.

54. Since announcement of the proposed Plant, Applicant has increased almost 100 percent its estimate for the total cost of the project. Costs have escalated because of public re-examination of nuclear power, be-

cause additional safety research has required amendment of the project in terms of hardware, and because of delays in connection with the licensing of nuclear power plants. Moreover, as Applicant admits, further delays are imminent because of an ongoing antitrust review not only delaying the proposed Plant but also resulting in the probability that Applicant may not be able to use in its system all of the electricity which could be generated from the proposed Plant. None of these delays or costs are evident in the construction of a fossil fired plant. Accordingly, the proposed Plant represents the selection of the most expensive and insufficient method of supplying any alleged demand for electricity and results in an unwarranted cost to the environment.

55. Assuming the validity of Applicant's assertion that it is necessary to build the proposed Plant for the production of electricity, Applicant has selected the wrong site for the Plant considering costs of generating electricity from other sites and considering the closeness to the proposed site to a large population center. Additionally, Applicant has not selected the most efficient method of dissipating waste heat inasmuch as cooling towers, and specifically dry cooling towers, represent a better alternative than does the inadequate cooling facilities presently planned by Applicant.

VIII

SURVEILLANCE AND MONITORING PROGRAMS ARE NOT COMPLETE AND ARE INADEQUATE IN ORDER TO ASSESS FULLY THE ENVIRONMENTAL IMPACT OF THE PROPOSED PLANT

56. Assuming that Applicant will construct the proposed Plant, during the period of construction and thereafter, inadequate monitoring and surveillance programs and measures have been taken by Applicant or suggested by the Regulatory Staff. As a consequence, Applicant will not, unless different monitoring and surveillance programs are adopted, be able to assess adequately the environmental impact of the proposed Plant to be in a position to take remedial and prophylactic measures. Intervenors contend that pre and post operational surveillance programs in connection with radiation, thermal, chemical, and noise emissions from the proposed Plant are deficient in at least the following respects.

57. The radiation surveillance program planned by Applicant is not sufficient adequately to monitor the effects of the proposed Plant:

(a) Applicant's proposed radiation monitoring program will not provide, in the areas for which it is intended, a sufficient understanding of background radiation and additive radiation created by the proposed Plant because there are too few monitoring sites selected and because the frequency of monitoring at such insufficient sites is too irregular.

(b) There are, Intervenors contend, several other areas of radiation effects which Applicant does not plan to monitor at all. It is Intervenors contention that a substantial monitoring of such areas must be made pre and post operational in order adequately to assess the environmental impact of radiation emissions from the proposed Plant. These areas are:

1. Phytoplankton;
2. Aquatic plants other than phytoplankton;
3. Terrestrial plants, including agricultural crops;
4. Zooplankton;
5. Benthic organisms;
6. Agnathans;
7. Osteichthyes;
8. Amphibians;
9. Reptiles;
10. Aves;
11. Mammals;
12. All sources of food grown or produced within a 50-mile radius of the proposed Plant, which food may be consumed within or without the 50-mile radius of the proposed Plant.

The radiation monitoring and surveillance program with respect to the above areas should be of a sufficient scope so that the monitoring will detect effects of direct radiation, such as directly on to soil and plants, and indirect radiation such as when a terrestrial animal consumes a plant that has been irradiated

or when a man eats a terrestrial animal which has consumed a plant which has been irradiated. Moreover, the program should include methods to determine concentration and biological magnification of radiation in the entire food chain. Intervenors contend that without such monitoring programs, an adequate environmental assessment of radiation risks and costs will not be made; and also without proper surveillance and monitoring, Applicant and the Regulatory Staff will be unable to take remedial and prophylactic measures regarding radiation effects.

58. Surveillance and monitoring of thermal effects from the proposed Plant are inadequate in that sufficient sites are not provided for and at such insufficient sites, the frequency of monitoring is inadequate. Moreover, the description of the Thermal Monitoring Program is so vague so as not to provide a meaningful point of departure for a substantive discussion. Additional sites should be provided on the River, Bullock Creek, Saginaw River, Pine River, Chippewa River, Cass River, and Lake Huron. The scope of the Thermal Monitoring Program should be sufficient so as to assess the thermal effect upon all organisms which inhabit each of the bodies of waters or rely upon each of the bodies of waters as a source of food and water.

59. Applicant does not propose and the Regulatory Staff has not suggested monitoring the indirect effects of thermal discharges from the proposed Plant. Thus, the health and development of terrestrial plants and animals may be adversely affected by changes in ambient air temperature due to thermal discharges.

60. Despite the fact that chemicals will be discharged into various bodies of water both by Applicant and

Dow as a result of the operation of the proposed Plant, neither Applicant nor Dow has been required to develop monitoring programs of sufficient frequency and scope with respect to such chemical discharges. Intervenors contend that the absence of any monitoring of chemical discharges represents a failure in an adequate environmental analysis.

61. Applicant has neither discussed nor proposed to monitor noise pollution which will be created by the construction and operation of the proposed Plant. Applicant should establish a monitoring program of sufficient frequency and scope so as to be able to monitor noise pollution and its effects upon man and other animals.

62. In addition to monitoring and surveillance by Applicant, since Applicant, Dow Chemical, and the Regulatory Staff have supported the construction of the proposed Plant at least in part so as to provide a benefit to Dow Chemical Company, in return for the benefit it will be receiving, Dow must have environmentally clean hands. Accordingly, Dow Chemical Company should be required to monitor its discharges in the areas of thermal, chemical, and noise from its own facilities so as to determine whether it should be rewarded with low-cost energy for purposes of expansion of its facilities. Dow Chemical's monitoring and surveillance should include frequency and scope at least as comprehensive as Intervenors have contended should be required of Applicant.

63. Intervenors contend that the cost of a monitoring and surveillance program discussed in this section should be borne by Applicant and Dow Chemical Company and not passed on to the public by requiring the Michigan Water Resources Commission to do the work.

IX

PROCEDURAL INADEQUACIES WITH RESPECT TO THE REGULATORY STAFF DRAFT DETAILED ENVIRONMENTAL STATEMENT

64. The National Environmental Policy Act requires the Atomic Energy Commission to make an independent detailed environmental analysis concerning the licensing of the construction of the proposed Plant. Situated throughout this Statement of Contentions are areas of environmental impact which the Regulatory Staff has failed to consider. Accordingly, the Statement is insufficient as a matter of law for not considering such areas.

65. The Regulatory Staff has illegally contracted its obligation to prepare the Draft Statement to Argonne National Laboratory. The arrangements between the Regulatory Staff and Argonne are unknown to Intervenors and, accordingly, they cannot make further contentions with respect to the procedural inadequacies of the relationship. For example, we do not know whether Argonne was requested to do independent analysis or whether, as appears from the Draft Statement, Argonne and the Regulatory Staff have only accepted, uncritically, submissions by the Applicant.

66. Based upon information and belief, Intervenors contend that the Regulatory Staff and its contractees have failed to provide an independent, substantive review required by the National Environmental Policy Act.

67. The Draft Detailed Statement fails to incorporate all of the information upon which it is based and fails

to include a complete discussion of all sides of a particular issue. As such, the Draft Detailed Statement is an incomplete environmental analysis and is insufficient as a matter of law.

68. The Regulatory Staff has failed to secure comments on a realistic schedule from all of the Federal, State, and Local agencies which have an interest in commenting. Moreover, because the Regulatory Staff has only provided for a less than 30-day comment period (considering mailing time), there is insufficient time for various of the agencies adequately to comment upon the Draft Detailed Statement. Accordingly, this procedural inadequacy built into the Regulatory Staff's preparation has resulted in an inadequate analysis.

69. The Regulatory Staff has failed to quantify and qualify in monetary terms all the costs, risks, and alleged benefits with the result that a sound, economic environmental analysis cannot be made. Moreover, the Regulatory Staff has as yet to prepare, for the guidance of Applicant, guides for preparation of environmental reports by those who are seeking construction permits. As such, the Regulatory Staff has failed to implement its obligations pursuant to the National Environmental Policy Act.

70. The Regulatory Staff has not required sufficient detailed preparation by Applicant of all areas of environmental concern and, therefore, in its implementation of its responsibilities under the National Environmental Policy Act, the Regulatory Staff has failed to acquire adequate investigation and reports by Applicant and its consultants.

71. The Regulatory Staff has failed to describe all risks inherent in the generation of electricity by nuclear power; and, accordingly, the Draft Detailed Statement is incomplete. For example, the aspects, both in terms of destruction of life and property, of a postulated loss of coolant accident resulting in an uncontrolled meltdown are not factored into the Regulatory Staff's Draft Statement.

72. The Regulatory Staff has failed to consider the actual cost of generating electricity through nuclear power. The actual cost includes such direct and indirect costs as increased cancer and leukemia, medical costs relating to those and other diseases from radiation exposure, and costs of decommissioning the proposed Plant when its defined useful life is over. The failure of the Regulatory Staff to have considered these costs, as well as the cost of disposal of high and low level radioactive wastes results in the Draft Detailed Statement being insufficient as a matter of law.

X

ENVIRONMENTAL CONTENTIONS WITH RESPECT TO THE ALLEGED NEED FOR POWER GENERALLY AS WELL AS FROM THE PROPOSED PLANT

73. The issue of demand for power or need for power is not a function of a simple application of projected figures to rated generating capacity. In the last two decades, we have seen a demand for electricity multiply, at least as interpreted by the utilities, the power industry, the Atomic Energy Commission, and other administrative agencies. A simple arithmetic exten-

sion of the present demand curve, as so asserted, makes it clear that in a very short period of time our economy will not be able to meet such a demand. There has been a failure to do any analysis as to means to create a *decrease* in demand for electricity or an elimination or curtailment of industrial and other uses of electricity which could be decreased or eliminated so the economy does not suffer in terms of goods and services. From a long range environmental standpoint, the social and scientific stimuli currently being injected into our economy encouraging peak uses of electricity must be eliminated. It is in this sense, as well as in the more practical sense of an analysis of actual figures produced by Applicant and the Regulatory Staff, against which any need or demand for power must be analyzed.

74. Intervenors contend that under the National Environmental Policy Act the proposed Plant may not be licensed unless it is demonstrated that the electricity allegedly needed from the proposed Plant, is unavailable to Applicant and/or the users in Applicant's area from any other source and, unless it is demonstrated that such demand for electricity represents useful social stimuli considering the long range rationalization of our national energy policy.

75. Intervenors contend that any demand for electricity generated by advertising or promotional efforts or by competition among public utilities to encourage the use of electricity cannot validly be rewarded pursuant to the National Environmental Policy Act.

76. Intervenors contend that in making an analysis of the promotional or advertising aspects of any demand for power, one must analyze actual advertising figures the

results of advertising campaigns, and a comparison of those results with statistics in areas, if any, where promotional advertising as a function of demand has not taken place. Moreover, any environmental analysis must consider whether a demand is created by encouraging the public to use unnecessary or non-utilitarian products which use large amounts of energy in the course of fabrication and production. Thus, if any portion of Applicant's demand is directly related to the production of such goods, an analysis has to be made as to whether the production of such goods should be encouraged or whether by a denial of electricity, one encourages the production of alternative goods which have similar end uses, but which require substantially lesser amounts of electrical energy to produce.

76A. Intervenors contend that notwithstanding promotional or advertising efforts and notwithstanding the lack of analysis of the end uses of energy, Applicant and the Regulatory Staff have failed to set forth adequately a responsible record upon which to substantiate claims for demand or need for electricity from the proposed Plant.

77. Applicant recently announced (January 1972) that it was cancelling construction of a Combined Cycle Plant because its statistics underlying the demand and the need for such a plant had been re-evaluated and were not correct. The same demand figures, which Applicant has admitted are no longer up to date, are being used to support the claim for demand for electricity from the proposed Plant.

78. Applicant's survey and analysis leading to its projected load forecasts is unsound in that it overstates

the future industrial needs of Michigan, the future population growth of Michigan, and fails to recognize that demand for electricity will decrease on an absolute and percentage basis. Moreover, Intervenors contend that Applicant has not considered all generating facilities which would be available, given certain interconnections, to consumers in its franchise area and, accordingly, Applicant has used a statistically erroneous geographic area in which to analyze a demand for electricity. Thus, Applicant's statement of electric reserves is misleading in that it does not cover all available reserves.

79. Applicant and the Regulatory Staff's analyses assume that the need for power is constant and firm and will remain so during at least the ten year period between 1970 and 1980. There is no basis for making this assumption or relying upon statistics during the period 1960 to 1970 because the factors governing each such period are not identical. For example, the rate of population increase during the ten year period, 1960 to 1970, was significantly greater than is or will be the rate of population increase during the period 1970 to 1980. Applicant's analysis has not taken into account this difference.

80. Applicant's analysis with regard to projected power needs is based, in substantial part, on past statistics. Applicant does not take into account that much of the power generated in earlier base periods was of a horizontal character in the sense that areas which never before had access to electricity were provided a source of electricity. Applicant and the Regulatory Staff have not taken into consideration in their projected land forecasts that such needs for electricity have

already been met by virtue of existing generating capacity.

81. Applicant's projection assumes a continued growth and development of industry in the State of Michigan. Applicant has not adequately assessed the fact that there is a national and statewide conservation movement which may severely inhibit increases in industry. Applicant also has not considered the possibility that industry in Michigan will seek to expand elsewhere and, thus, not be available to support an alleged increase in demand.

82. Applicant and the Regulatory Staff assert that the electricity from the proposed Plant is needed in order to maintain a rate structure which is competitive with the cost of energy in other States. Applicant fails to recognize that the National Environmental Policy Act requires a long range analysis and, as such, does not permit Applicant to assume that somehow the State of Michigan and Applicant are to be favored over some other area. It may be inconsistent with the National Environmental Policy Act and a rational resolution of our National Energy Policy to encourage further electricity uses in the State of Michigan. Finally, in its so-called competitive analysis, Applicant has failed to take into account what effect, if any, the increased purchase of power (by virtue of a national interconnection of grids) would have upon the alleged need for power.

83. Applicant has failed to analyze its need for power in light of any environmentally sound program to share electricity with coordinating utilities within and without the State of Michigan and, particularly, municipalities and consumer owned cooperatives.

84. Applicant and the Regulatory Staff have in part asserted a need for power from the proposed Plant in order to retire older, less efficient, fossil fired plants, However, Applicant has failed adequately to compare the reliability of fossil fired plants with the reliability of nuclear power plants and the proposed Plant.

85. Applicant asserts that the proposed Plant is necessary to provide "a plentiful and inexpensive supply of electricity . . . to maintain and enhance the living standards. . . ." Applicant has failed to analyze, however, either the need to conserve energy resources, a need which appears to be environmentally more sound than a need to make energy resources more plentiful. Applicant does not state whose living standards are going to be increased by the proposed Plant, and it does not analyze whether any substantial segment of the population's living standards may be decreased as a result of the proposed Plant in terms of a degraded environment which would adversely affect health, life, and property.

86. Applicant's projected demand erroneously assumes that all future needs for electricity will be increased or new demand and will not reflect merely replacement demand. For example, it is true that there may be increased residential construction; however, Applicant ignores that a person who builds a new home may be, at the same time, vacating an old home — which new home would not, therefore, represent an increase in demand for electricity.

87. There is no basis for Applicant's assumption that room air conditioners will increase from 160,000 to 360,000 in four years and that they all will be used at

peak periods, particularly if the citizens are educated to conserve energy.

88. Applicant has misanalyzed the projected growth of its major users of electricity such as General Motors and Dow Chemical. The projected increases in production and uses of electricity by such major users are inordinately high in light of the rate of population for the applicable base period and the national movement to conserve electricity. Concomitantly, Applicant has failed to factor into its projection the possibility that rate structures will be revised so as to make large use of electricity on a per unit basis more expensive thereby discouraging the increased use of electricity.

89. Applicant has erroneously assumed that the Gross National Product will continue to spiral. The relationship which the Applicant asserts exists between the automobile industry and the Gross National Product does not take into consideration that many metropolitan areas, including those in the State of Michigan, are encouraging the development of mass transit which would result in a relative decrease in the production of automobiles.

90. Applicant has incorrectly stated the current demand for electricity in light of reports by the Edison Electric Institute and the Association of Electrical Illuminating Companies. The Annual Report published in late 1971 by the Edison Electric Institute disagrees with Applicant's assertions as to the character and scope of a so-called "power crisis."

91. Applicant's projections with respect to electrical needs for street and highway lighting are unsound. Applicant's own figures show a decrease in street and high-

way lighting for the years 1971 and 1972. These figures do not support Applicant's projections for the years 1973 and beyond, particularly since highway and super-highway construction has and will become more limited.

92. Applicant has not provided any support and, accordingly, its analysis is unsound, with respect to its claim for the need for electricity will provide jobs for an increased number of adults. Once again, Applicant's projections have failed to take into account the environmental movement and the demands of society for industrial progress and national growth consistent with environmental protection.

93. Applicant's need for electricity insofar as it relates to its claim to further an improvement in air and water quality is specious, since Applicant fails to take into account the effects upon the environment, (absolutely and relatively by virtue of a cost-benefit analysis) of the production of electricity which assertedly will be used to replace alternative forms of the production of electricity.

94. The Regulatory Staff in connection with the need or demand for power has failed in its obligations to make an independent analysis, but rather has accepted, uncritically, statements of the Applicant.

XI

CERTIFICATION OF MICHIGAN WATER RESOURCES COMMISSION

95. Consistent with the Calvert Cliffs' decision, the Atomic Energy Commission has an obligation to evaluate and analyze state water qualify standards and revise such

standards in the event that they provide insufficient protection for the environment. Intervenors contend that the Water Resources Commission standards and its Water Quality Certification for the proposed Plant are based upon inadequate water quality standards. Accordingly, the National Environmental Policy Act requires the Atomic Energy Commission to review and upgrade such water quality standards.

96. The local laws of the State of Michigan (Section 6(a) of the Public Act 245 of the Act of 1929) makes it unlawful to discharge any substance into the state waters which is or may become injurious to the public health, safety and welfare. The state law does not provide an exception to permit discharges into state waters which may result in a concomitant benefit in an unrelated area. Accordingly, the Water Resources Commission has no authority to permit Applicant to make any discharges into state waters from the proposed Plant, and the Atomic Energy Commission may not, therefore, rely upon such an invalid water quality certification in the licensing of the proposed Plant.

97. The Water Resources Certification permits Applicant too long a period of time to report excesses of standards established by the Water Resources Commission. More frequent reporting is necessary to prevent negligent or intentional violations of the established water quality standards.

98. The Water Resources Certification is based upon a classification of differing standards for differing bodies of water throughout the State of Michigan. The Water Resources Commission has no such authority in light of the laws of Michigan, and the National Environmental Policy Act does not permit such a

classification which, by its operation, subjects some bodies of rivers to environmental degradation. Accordingly, the Water Resources Certification is based upon an illegal standard.

99. Assuming the validity of a classification of standards for bodies of rivers, the Water Resources Commission classification is insufficient in that based upon the existing quality of the River and Bullock Creek, the operation of the proposed Plant will violate all standards set forth by the Water Resources Commission in its Certification for the River and Bullock Creek, and more specifically described in (110) below. As such, the Water Resources Certification is insufficient.

100. The Water Resources Commission states that it is changing the designation of the River essentially from a standard of "tolerant fish" to a better standard of "intolerant fish." This change, due to become effective January 1, 1974, will not be able to be achieved if Applicant is permitted to operate the proposed Plant at the proposed site and as currently designed. This is particularly true in light of the fact that other industries, including, but not limited to, Dow Chemical Company and Dow Corning Company, continue to pollute the River and its confluences. Accordingly, permission to Applicant, in light of the circumstances, represents an unwarranted cost to the environment.

101. The Water Resources Commission Certification has failed to take into account the standard or criteria for discharges proposed by Applicant into Bullock Creek, and, thus, the Water Resources Certification is incomplete.

102. The Water Resources Certification has erroneously concluded that the operation of Applicant's proposed

Plant will not violate the standards set for total dissolvable solids in the River. This is because the analysis of Applicant's contribution to total dissolvable solids does not consider Dow Chemical's contribution and Dow Chemical's increased contribution as a result of planned expansion due to, assertedly, low cost energy and process steam from the proposed Plant. Moreover, the discharges of total dissolvable solids by Dow Chemical are downstream from those proposed by Applicant, and, accordingly, the geographic point in the River used as a basis for Applicant's analysis is unrealistic and does not result in a true analysis of the actual amount of total dissolvable solids which are or will be contained in the River.

103. The standard set by the Water Resources Commission with respect to the amount of total dissolvable solids permitted to be discharged in or accumulated in the River is qualitatively unsound in that it does not consider the highly injurious and toxic effect of certain classifications of total dissolvable solids such as the solids resulting from the massive daily discharges by Dow Chemical of chlorinated hydrocarbons. Thus, the standard set for the total dissolvable solids, a standard which permits certain additions to the total dissolvable solids by Applicant as a result of the proposed Plant, is insufficient to protect or upgrade the water quality of the River.

104. The Water Resources Commission has established maximum temperature levels for the River. Intervenors contend that as a result of operation of the proposed Plant and, particularly during a drought year, such as was experienced in 1944-1945, the maximum allowable temperature levels will be exceeded

at points in the River below the Dow Chemical Waste Water Treatment Plant.

105. The Water Resources Commission has used the base year 1975 in its Certification. The use of the year 1975 as a base year has resulted in an inadequate analysis underlying the Certification. This is because subsequent to the year 1975, when Applicant's proposed Plant will be operating, tables of electric power use and projected growth of Dow Chemical indicate that Dow Chemical Company will be discharging substantially more pollutants into the River and, thus, the additive effect of Applicant's discharges will be far greater than has been assumed by the Water Resources Commission. As such, the Water Quality Certification is inadequate.

106. The Water Resources Commission has set a standard fo, the average content of dissolved oxygen in the River to be not less than five milligrams per liter and in any specific instance, not to be less than four milligrams per liter. Intervenors contend that this standard is insufficient. Moreover, assuming the validity of this standard, it is obvious from an examination of the statistics thus far provided that, currently, the standard is being violated and the additional discharges from the proposed Plant and the resultant expansion of Dow Chemical will inhibit and prevent any ability to meet or maintain the average and specific standard for the River with respect to the dissolved oxygen content.

107. The Water Resources Certification notes major accidents which resulted in adverse effects upon the River, including fish kills on at least two occasions, to wit: on September 14, 1969 and July 27, 1971. The Water Quality Standards set for the River and the

resultant Certification have failed to take into account adverse effects upon the River as a result of accidents of the frequency and severity as those exemplified and described in the Certification. As a result, the Certification and the setting of Water Quality Standards is based upon the unrealistic assumption that the River will only be subjected to the discharges as a result of normal operations. The failure of the Water Resources Commission and its Certification to factor a margin of error for its predictions of discharges into the River including, but not limited to, abnormal discharges, results in the Water Quality Standard being insufficient to protect the River in accordance with law.

108. The Water Resources Commission has established that the coliform count in the River may not exceed 5,000 organisms per milliliter on an average count. There are included within the Water Resources Certification instances of coliform counts which exceed the established standard. Intervenors contend that the total coliform density in the River already exceeds the Water Resources Standards for intolerant warmwater fish and agricultural use during substantial portions of the year and that the operation of Applicant's proposed Plant and any expansion of Dow Chemical will compound these problems by virtue of additional discharges of sanitary wastes which increases the total coliform density.

109. The Water Resources Certification sets forth an established standard governing the River with respect to temperature limits for mixing zones and the edge of mixing zones. However, this Water Quality Standard is inadequate in that the standard does not define the mixing zone absolutely or specifically with respect

to thermal discharges by Applicant or Dow Chemical. As such, the Water Resources Commission Certification represents inadequate protection of the River.

110. The Water Resources Commission has set forth in its Certification Water Quality Standards applicable to the River and other bodies of water for suspended colloids, residues, toxic and deleterious substances, nutrients, phosphates, ammonia, nitrates, sugars, taste and odor and pH. Intervenors contend that discharges from the proposed Plant and from the expansion of Dow Chemical resulting from operation of the proposed Plant will separately and/or in combination cause an increase in total amounts with respect to each of the above areas which will lead to absolute and relative values exceeding the Water Quality Standards and thereby contribute to the degradation of water quality of the River and its confluences.

111. The Regulatory Staff has made no independent review of the Water Resources Certification so as to form an independent judgment upon the Certification or the Water Quality Standards upon which it is based. Accordingly, the Regulatory Staff has failed to meet its obligations pursuant to the National Environmental Policy Act as interpreted by the Calvert Cliffs' decision.

XII

ADVERSE EFFECTS ON WATER USED FOR DOMESTIC PURPOSES AND/OR AGRICULTURAL IRRIGATION

112. Applicant and the Regulatory Staff assert there will be no adverse effect on the domestic water supplies in the greater Tri-City area as a result of the opera-

tion of the proposed Plant. However, neither Appli cant nor the Regulatory Staff has presented and analyzed any data indicating survey of seeps or springs coming into the River. Furthermore, there is no data relating to a recharge of ground reservoirs by the River. The failure of Applicant to have analyzed seeps or springs or recharge or ground reservoirs indicate that Applicant and the Regulatory Staff's assertions with respect to effects, if any, on domestic water supplies are insupportable. Moreover, Intervenors contend affirmatively that based on available statistics that there will be an evaporative loss from the cooling pond to the River in the range of 20 to 35 cfs which will influence the total recharge of ground water reservoirs which will adversely affect the amout of water available to wells in the Tri-City Region, particularly, downstream from the proposed Plant. Thus, not only have Applicant and the Regulatory Staff failed adequately to analyze these crucial criteria, but the available statistics indicate that operation of the proposed Plant will have an adverse effect upon domestic water supplies.

113. Applicant has admitted that in its franchise area, including the area to be serviced by the proposed Plant, there exists agricultural land which is, from time to time, subject to irrigation. Applicant has not analyzed the effect which the generation of electricity and transmission of electricity from the proposed Plant will have upon the inability of owners of agricultural land to irrigate their crops. Grids and transmission lines will prevent the agricultural land situated near such grids and transmission lines from being irrigated by conventional sprinkler systems. The failure to have considered as a cost to the environment the

amount of agricultural land which will be affected has not been considered in the cost-benefit analysis.

XIII

INADEQUATE ANALYSIS FROM EFFECTS OF MAJOR AND SEVERE FLOODS

114. Applicant and the Regulatory Staff have presented data on a probable maximum flood and assert that the design of the proposed Plant adequately safeguards the Plant from such a probable maximum flood. Intervenors contend, however, that an adequate environmental analysis is not possible unless it includes the probability and effects of a 10-year, 100-year, 500-year, 1,000-year or 10,000-year flood and that the 634 foot site elevation established for the proposed Plant will be insufficient to protect the proposed Plant in most of the above floods. In addition, Applicant's failure to discuss the range of possible floods has resulted in its failure to consider or take into account such a range of floods in connection with the design of the under-structure of the proposed Plant or the emergency measures which would be necessary to be taken into account in the event of such a flood or floods. In any such analysis, Applicant must set forth statistics upon which one can conclude what the degree of probability is with respect to each such flood and must also set forth what the consequences would be from each such flood. Without such information, an adequate cost-benefit analysis cannot be made.

XIV

AREAS IN WHICH THERE IS NO DISCUSSION RESULTING IN AN INCOMPLETE ENVIRONMENTAL ANALYSIS

115. Applicant and the Regulatory Staff have failed to consider in their environmental submissions any information or substantial information in each of the following areas. The failure to have analyzed and considered issues in such areas results in an insufficient environmental analysis of the construction and operation of the proposed Plant:

(a) Social and philosophical effects of the displacement of people as a result of the construction and operation of the proposed Plant;

(b) Wildlife aesthetics;

(c) Population projections;

(d) Chemical explosions at Dow Chemical and Dow Corning Companies;

(e) Effects of synergism between radiation and chemicals;

(f) Effects on fish and other organisms as a result of the operation of intake structures;

(g) Decrease in property values as a result of each cost considered or failed to be considered;

(h) Effects of the construction and operation of transmission lines, including but not limited to, effects in the following areas:

(i) visual aesthetics;

(ii) displacement of land; and

(iii) effects on bird migration.

XV

INADEQUATE COST-BENEFIT ANALYSIS

116. The National Environmental Policy Act requires sufficient information in order to make a cost-benefit analysis both qualitatively and quantitatively. The Regulatory Staff and Applicant have not presented sufficient information and have expressly declined to make qualitative and quantitative analyses of the various costs and benefits discussed in each of their submissions as well as those raised in this Statement of Contentions. Rather, Applicant and the Regulatory Staff have put forward certain value judgments and conclusions without assessing their economic cost or benefit and without relating such value judgments to the standards of the National Environmental Policy Act.

117. In certain instances, Applicant and the Regulatory Staff have provided dollar values but, once again, these dollar values are based upon vague or nonexistent factual support.

118. Intervenors contend that because the procedural failures listed in Contentions 116 and 117, there is a failure to comply with the provisions of the National Environmental Policy Act as well as a failure to provide a sufficient factual basis for this Board adequately to analyze the totality of the environmental impact of the direct and indirect effects of the proposed Plant.

XVI

MISCELLANEOUS

119. Intervenors also incorporate by reference each of the Contentions set forth in Appendix B to our Motions filed on September 30, 1971 and set forth in comments of the Environmental Defense Fund dated June 4, 1971.

SAGINAW VALLEY
INTERVENORS, ET AL.

Their Attorney

MYRON M. CHERRY
109 North Dearborn Street
Suite 1005
Chicago, Illinois 60602
312/641-5575